DISCOVERY

A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

Edited by L. Russell Muirhead

Volume XIX
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By F. S. Copeland

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The Sponge of Commerce

By N. W. Gregory Walker

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Atom Tracks : By Dr. Ruth Lang

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The Pyramid-Temple of Kukulcan — A Discoverer of the North-West Passage — Pigment of Caterpillars — Stone Age Man in Utah

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DISCOVERY

A Monthly Popular Journal of Knowledge

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Notes of the Month

IN times like these, when so much that is irreplaceable is being lost or destroyed, the Royal Institution has shown a commendable feeling of topicality in the choice of subject for its 112th course of Christmas "lectures adapted to a juvenile auditory." Dr. Julian Huxley is delivering a series of six lectures on *Rare Animals and the Disappearance of Wild Life*, on Tuesdays, Thursdays, and Saturdays, from December 28th to January 8th, at 3 p.m. He points out that the rarity of animals is due to a number of different reasons, such as man's interference, inaccessibility, or changes in natural conditions. Among other rare types of animals are unusual varieties, or survivals of a once common group. In his first three lectures Dr. Huxley reviews the various causes and classes of rarity; then he deals with local rarities and the few encouraging examples of once rare animals that are beginning to spread again; and finally he tackles the problem of what can now be done. Organisations have done and are doing much splendid work, but the most satisfactory method of preservation is to set apart special areas—National Parks—where wild life is strictly protected.

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In its 17th Annual Report the National Institute of Industrial Psychology records an increase in the number of investigations into the conditions in factories and offices; it is noteworthy that ten investigations were undertaken for businesses that had already had experience of the Institute's services in past years. Details of these investigations show how many aspects of industrial and commercial enterprise have been examined, including the selection and training of employees, the discovery of causes of their discontent, working conditions, production-planning and layout, the study of consumers' psychology, etc. The policy of the Institute differs from that of other organisations, which at first sight may seem to have an identical object. The Institute does not guarantee the employer a gain in output, nor does it aim, primarily, at increased production. Its immediate aim is the better selection and training of the rank and file, supervisors, and management, and the improvement of working conditions. It does not attempt to drive the worker to produce more, but it seeks to remove all obstacles, physical and mental, which prevent him from doing his best. This wide field is being further extended by the formation of a section dealing with management and the presentation of business statistics.

* * * *

The Association of Bird Watchers and Wardens, though founded less than two years ago, is already noted for its beneficent work in the cause of the preservation of wild birds. It is now announced that they have evolved a scheme of nest-adoption, in which owners of sporting estates will be asked to co-operate, by arranging with their gamekeepers to keep a watch for egg-collectors; also to refrain from shooting certain rare birds, especially during the nesting-season. A further scheme is associated with the plague of Foot and Mouth Disease. Rightly or wrongly birds have been blamed for the introduction of the disease into this country. If birds are responsible, starlings, from their habit of associating with sheep and cattle, are undoubtedly the culprits. It is important to settle this point as soon as possible as otherwise there may be an indiscriminate destruction of such immigrant birds as fieldfares,

redwings, etc. Experiments have been suggested which will decide whether it is possible for starlings to spread this disease.

* * * *

For some time past, considerable hostile criticism has been levelled at the Federal and State authorities in Australia regarding their treatment of the surviving aboriginals; and it is now reported that Mr. Lyons, the Commonwealth Prime Minister, intends to call an early conference of Federal and State representatives on the future of the native races. Mr. Lyons admits that there is urgent need for improvement in the treatment of the natives, but deprecates recent exaggerated statements. Dr. Donald Thomson, of Melbourne University, whose name will be familiar to readers of DISCOVERY, has expressed in no measured terms his feelings regarding the official indifference to native interests, and it must be admitted that the Government have shown courage in summoning him to Canberra to express his views to the Federal authorities. They may obtain further information concerning enlightened opinion on the subject by reading Robert Croll's *Wide Horizon*, recently published by Angus & Robertson (9s. 6*d*.) Mr. Croll makes the point that aboriginals who have adopted clothes become exceedingly dirty and unhealthy, whereas the untouched tribes retain their fitness and dignity of bearing.

This striking photograph of a rare albino flying phalanger arrived from Australia just too late to be included in Mr. Samuel's article in our last issue. Not only is the animal remarkable in itself, but the camera has caught it in a typical pose and showing a characteristic expression.

* * * *

Asbestos has been much in the news recently. Following the publication by the Imperial Institute of *Asbestos*, a new and authoritative volume (2s.), by G. E. Howling, comes the report that a demonstration of asbestos flying-suits was given at Slough, on December 8th, by the makers of the suits. Two widely different properties of this useful mineral are concerned. In Mr. Howling's book attention is concentrated on the value of asbestos as a protection from noise, and several ingenious applications are recorded. For sound insulation and acoustical purposes in buildings, a mixture of fine asbestos fibre and an inorganic liquid binding substance is sprayed by pressure on to the parts or walls to be insulated. In the case of the flying-suits it is the heat-insulating property of the mineral that comes into prominence; for these suits, only 12 lb. 9 ozs. heavier than the standard R.A.F. suits, afford just those few extra moments to the crew of a burning plane which may make the difference between safety and a painful death.

* * * *

On p. 21 of this issue is a brief biography of one of the earliest explorers of the North-West Passage. An official Canadian report now announces the successful crossing of a new and shorter passage between Atlantic and Pacific. The S.S. *Nascopie* of the Canadian Eastern Arctic Patrol met the schooner *Aklavik*, from the Western Arctic, in Bellot Strait, which separates Somerset Island from Boothia Peninsula, the northern tip of the Canadian mainland. This passage, discovered in 1852, has been under consideration by Arctic navigators since McClintock, who tried to penetrate it, but failed, on his search for Franklin in 1858. Indeed, no voyage by any Arctic route from the Atlantic to the Pacific was successful until Amundsen forced his way through the more northerly Barrow Strait route in 1903-7.

The Sponge of Commerce

By N. W. Gregory Walker

As fascinating as the life-history of the sponge is the story of the recovery and preparation of the varieties that are used commercially. The industry has changed but little throughout the ages, and though good sponge grounds are found off the Bahamas, the Eastern Mediterranean is still the most fruitful source.

THE sponge that we buy in a shop is the skeleton of the lowest of those living animals whose bodies consist of more than one cell. When taken from the sea it has a dark, slimy appearance, the flesh or tissue, when cut, resembling beef liver, except that it is riddled with cavities. The skeleton or fibre which supports it is composed of a substance (spongin) closely related to silk. Whether a particular sponge is to be regarded as an individual or a colony is hard to say, for it may be formed from a single larva or from the fusion of many. Separate sponges will coalesce, and minute fragments will make new sponges. So great is the sponge's power of regeneration that, if a piece of it is passed through fine silk so that the component cells are completely separated, these individual cells will combine to form a new sponge.

Without having a mouth, the sponge's one object in life—so to speak—is to draw in fresh water and to get rid of it when used. In its essential construction it is a collection of force pumps. Its surface is studded with minute pores through which currents of water enter the body, bringing food particles and oxygen. The water currents are driven through canals and pass out through large openings (*oscules*), carrying away waste products. At intervals the canals are dilated to form round chambers—the flagellated chambers—which are lined with collared cells. Each collared cell consists of a round body bearing a flagellum, the base of which is controlled by a funnel-like collar. Concerted action of the flagella—which, so far as observation has gone, move together in the same direction—draws water into the chamber. As this is already full its walls are stretched and a pressure set up that drives the water through canals which, uniting in larger and larger tubes, reach a *cloaca* leading in turn to the external vent or *osculum*.

It will be seen that the jet from the vent must reach well clear of the sponge so that the ocean current will carry away the used water and allow fresh food-bringing water to enter. Without a passing current the used water would be drawn down in a circle round the sponge and then reabsorbed uselessly. No sponge can live in stagnant water, which is why it is so hard to keep it under observation in an aquarium. It has been pointed out that the combination of jets from the flagellate chambers into few streams immensely decreases the friction surface of the expelled water, and so the combined jet is driven to a much greater distance than would be reached by a number of little jets using the same energy and discharging independently. The principle is that of a number of small businesses uniting to reduce overhead expenses. For certain sponges it has been shown by calculation that the diameter of the vent is that which will carry the water to the greatest possible distance for that make of sponge.

[*Photo: Hydra Sponge, Ltd.*

Mediterranean sponging-vessels: in the foreground, gangava, or dredging-boat; in the centre, scaphander or divers' boat, with crew of fourteen; behind, the depot-ship carrying six months' provisions and affording room for storing £4,000 to £6,000 worth of sponges.

It has been said that the sponge's food consists of microscopic animals and plants, such as protozoa, diatoms, and the minute larvæ of larger forms. At present this is guesswork, but there is a good deal to be said for the view that sponges feed on organic detritus, and are therefore, to some extent, scavengers. They seem to have no enemies, except that at times they are found to have been bitten by crabs. The sponge's normal method of reproduction varies, but in the horny sponges ova and spermatozoa seem to develop from the cells of the tissues. After fertilisation *in situ* the ovum

divides and subdivides until it forms a globe-like mass of cells, the rearmost of which have whip-like tails. In this form the little globes are expelled in masses from the effluent canals. There is enough power in their whips or cilia to drive them hither and thither, but presently they acquire a distaste for light and make for the bottom, where perhaps one in a million of them sticks on a favourable spot. Here the ciliated cells are tucked in and form the pumping system of the future sponge, while the smooth cells form its outer covering.

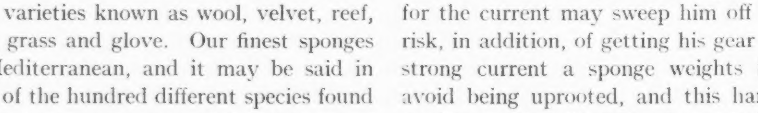
The fibre of a sponge may be of a glassy texture, or consist of sharp spicules cemented together with a horny substance, or again, this horny substance may form the whole skeleton, and it is from the group of these last-mentioned horny sponges that the commercial sponges are taken. These are a mere handful out of the ten thousand known species, and those worth gathering are found almost entirely in the Eastern Mediterranean and in the West Indies. The Mediterranean provides the market with the fine Turkey cup, the fine Turkey solid, the zimocca or brown Turkey, the elephant's ear, and the honeycomb sponges, in that order of value, and from the West Indies come, in similar order, the varieties known as wool, velvet, reef, hardhead, yellow, grass and glove. Our finest sponges come from the Mediterranean, and it may be said in passing that none of the hundred different species found off our own coasts have any commercial value.

According to the most recent figures available, the value of the imports of sponges into the United Kingdom for the year 1935 was, in round numbers, £145,000. £23,000-worth came from British possessions, which practically means the Bahamas. Of the imports from foreign countries, valued at £122,000, the Italian Aegean accounted for £70,000. Eighty per cent. of the Mediterranean fishery is carried on by Greeks under their own flag, and the remainder by Greeks resident in Tripoli. Paying grounds lie eastward of a line between Tunis and Sicily and thence as far as the Bosphorus. Here were the ancient sponge fisheries of Egyptians, Phœnicians and Greeks, and it is a fairly safe guess that as long as there has been a Mediterranean there have been sponges in it. To-day, the best Turkey cups—the cream of the fisheries—are found on the Mandrouka bank, north of Alexandria, and thence the finest specimens are found westward at Bomba, Benghazi and Sfax.

All varieties may be found anywhere within the main area, but quality is largely dependent on considerations of the depth and temperature of the water, the force of the current, and the nature of the bottom. The best depth is from 20 to 28 fathoms, and, though large sponges are fished at 30 fathoms, it is found that the greater the depth beyond that the poorer the quality. It may be taken that the limit of useful fishing is 35 or 36 fathoms, beyond which depth lack of light weakens the fibre. Sponges are sometimes spoilt by volcanic action warming the water or the sea floor. In this last case, though the sponge may grow, it is affected commercially by the root becoming weakened and flabby.

A suitable current may run up to five knots, though even then a diver cannot always get at good sponges, for the current may sweep him off the bottom, with a risk, in addition, of getting his gear twisted. In a very strong current a sponge weights itself with lime to avoid being uprooted, and this hardens and so spoils its fibre. Most "elephant ears," however, are found in the very strong current off Lampedusa (100 miles west of Malta), and it is likely that the flexible vase-shape of this large fine-textured sponge enables it to resist a rush of water.

A sponge torn from its hold does not die but becomes a "roller"—round, hard-fibred and useless for market. It should always be remembered that sponges of the same kind often vary in form according to the conditions under which they grow. It is possible, for instance, to see an amorphous specimen which has become so bewildered, so to speak, by find-



[Photo: Hydra Sponge, Ltd.

Mediterranean sponges drying in the sun on trays.

ing itself in changing eddies, that its surface is a mass of odd-looking projections. The best specimens are found on a rock bottom or under a ledge, but sponges will hold on to anything, from seaweed to an ancient wine jar. Lastly, even under the best conditions of growth, they must not be thought of as evenly distributed but as growing in patches like mushrooms.

[*Photo: N. Vouralis & Co., Ltd.*

Sorting sponges at Nassau, Bahamas.

Besides being dredged or harpooned—not to mention being found by wading in shallow water—Mediterranean sponges are obtained by diving. Naked diving still goes on off Benghazi, Tripoli, and the island of Symi, in a depth up to 20 fathoms. The Greek boy of the islands early practises diving for pennies in rivalry with his mates. From his parents—especially his mother—he gets little encouragement to go to sea, but in the hilly and so more barren islands he has no choice. He is a deck-hand at the age of sixteen and a diver when he is twenty-two. When diving naked he holds a flat stone of a special shape, by which he is able to direct his descent to the spot he chooses. His usual time of submergence is three minutes, but he can stay down for four, without the aid of even a nose-clip. He will do this for about two hours in a day and continue at his trade until he reaches the age of forty. It is maintained that the lungs of a naked diver adapt themselves to the work, and that he suffers no injury.

Most of the diving, however, is done with the full diving dress or scaphander. The scaphander diver runs little risk from sharks, for though his appearance arouses their curiosity, so that they will come within two yards of him, they will not attack. If he thinks a shark is too close to be pleasant he has only to release some air bubbles from his helmet to frighten the creature away. Sharks have attacked native divers, who leave the water the moment they see one large enough to be dangerous. Octopuses, sometimes a menace to divers, seem to have caused no injury among sponge fishers.

The captain of a sponging boat has a "feeling" for good fishing grounds. He has also a great deal of knowledge which he keeps a secret. When he is over one of his known grounds he will never send down a diver if his vessel is under observation by another boat. His private knowledge dies with him unless, as is usually the case, he has sons trained to continue his work. Many of the best sponges, for example the mandroukas, may be hidden in weed up to two feet high. There are divers who fill their nets again and again on such ground, while a man next them may find nothing. The secret seems to lie in a capacity to detect a cloudiness in the water, which hangs above a hidden sponge. As a Greek put it to the present writer, the sponge "throws a spit."

The divers sometimes find more than sponges. The following story is told by Mr. J. S. Tsipis, director of the firm of Hydra Sponge, Ltd., which has its own fleet of vessels. In the year 1888, a diver for Mr. Tsipis's grandfather found on the sea floor near Hydra a group of short columns standing upright in a square. The diving captain was so interested in the man's report that he went down himself and, scratching one of the columns with his knife, found that it was made of silver. Further examination showed that the columns were composed of French silver coins, dated about the year 1600. These had been packed cask-fashion in wooden staves which had crumbled away, leaving the coins caked together. The diving boat was of 15 to 20 tons capacity, but her crew loaded her with silver to the boom. On reaching Hydra all hands carried the money to a warehouse, using sacks, basins, or anything that came handy. Sometimes the receptacles burst, scattering the coins, to the great delight of the inhabitants who followed the procession. All that night the womenfolk went over the route, picking up coins that had fallen and lodged in the stones. Next day came down the port admiral, to claim rights in the treasure. When he was satisfied, there was left a balance of but fifteen per cent. of the find to be divided between the captain and his crew. Even so, however, they had made a most profitable voyage.

In the Bahamas all fishing is in the hands of negroes

and is done by "hooking," the implement now generally used having a single curved blade. The men usually work at a depth of 6 to 7 fathoms, though many small sponges are secured by wading offshore in three or four feet of water. West Indian sponges are found by the use of a bucket with a glass bottom, which gives a clear view below the ripple on the surface. Marketable stuff is obtained on all bottoms, whether rock, sand or weed. Sponges growing on rock are the best, and those on weed the poorest. Sand tends to weaken the root and weed often spoils it by interpenetration. The chief fishing ground is the Great Bahama Bank, known as "The Mud," a floor of soft calcareous ooze, 200 miles long by 60 wide, stretching west and north from Andros. The Little Bahama Bank, or "Southern Mud," is 143 miles long by 10 to 38 broad, and lies west of Abaco.

Nassau and Florida Sponging

The fishing is done by schooners carrying small dinghies or dories. As is the practice in the Mediterranean, the sponges are spread on deck until the flesh softens in the sun, and can be removed by beating and treading, followed by washing overside. As the flesh must decay before it can be separated from the fibre the process is a messy and smelly one. Sometimes much is done ashore by soaking the sponges in a tidal pool, and in all cases the cleaned fibre is bleached in the sun. The market product is sold by auction at Nassau—the buyers being chiefly Greeks—and is shipped tightly pressed in bales. The cruises last from five to eight weeks, and the payment of all hands depends on the success of the voyage, the owner of the boat receiving one-fifth to one-fourth of the gross proceeds. After having made a good trip it sometimes happens that a negro captain and crew charter a boat and get her provisioned on credit. Then, working round the coast, they land at some pleasant spot where, singing and dancing in the company of women friends, they pass several happy weeks ashore. Before returning they fill up as best they can with rubbish, such as reef sponges or material washed ashore in the surf. They, of course, bring a pitiful tale of unsuccessful fishing, and, though the Nassau outfitter who furnished the stores has a claim on the profits, that benefits him little in the case of an unsaleable cargo. One unfortunate storekeeper, motoring from Nassau, came on a sponging crew ashore and revelling in the provisions which he had just supplied.

Florida sponges in general are inferior to those brought into Nassau, but the whole supply is nevertheless absorbed by the United States. Greek scaphander divers work the west coast of the peninsula, up to ten fathoms, from the Keys to Cape San Blas, as well as a bank in the Gulf, 130 miles offshore. Of these last fishers a writer in the *Atlantic Monthly*, declares, "The deep-water boats are unhappy ships. They frequently bring men up from twenty fathoms very sick with the bends. Since it has been learned that putting them back in the water again, while unconscious, is helpful, there have been few fatalities. But it means months in the hospital—and the sooner ashore the better."

The Future of the Sponge Trade

Though prices have risen, the Nassau sponging industry, which is the mainstay of the group, is only half its former size, partly because of the closing of some of the grounds and partly, it is claimed, from lack of up-to-date methods. There can be no such thing as complete exhaustion of a bed, though it may be so stripped that for a time it does not pay to work it. This raises the question of depletion. Mr. A. Pelecanos, a London sponge importer, considers that a mere improvement of fishing methods would be likely to bring the industry to a standstill for lack of material, and, though it is not easy to get definite information, it seems that the Florida fishers have for some time been forced to go deeper and deeper to fill their boats. What exhausts a bed is the destruction of little sponges. A Mediterranean diver is paid by weight, and, though he leaves odd sponges at the outside of a clump, he grabs handfuls of both big and little. A West Indian diver is not allowed to sell sponges beyond a certain size, but this only means that they are tested with a gauge ring when brought up, and, if undersized, thrown away. Both in the Mediterranean and the West Indies, beds are periodically rested in turn for one or two years, but boats naturally concentrate on a supply which has just been opened, and a sponge needs four or five years to reach a good growth. The Egyptian government adopt the sound principle of protecting the valuable Mandrouka bank by allowing it to be fished only after the issue of a limited number of licences. An attempt has been made at British Honduras to establish culture fisheries in lagoons, but so far little in this direction has been done, either there or at Nassau. By this artificial method picked sponges are taken to the breeding-ground, where they are used to supply cuttings. One such pedigree sponge will provide as many as 2,000 cuttings over a period of 30 years, but each cutting has to be fastened by a wooden peg to a cement disc, while if the sponge is taken out of water for two minutes it will be dead or useless.

A bath or face sponge need not be dear, and many a man provides for cleaning his car a better specimen than that which, at twice the figure, he buys for his personal use. The public pays too much attention to shape, which accounts for half the price, and does not

affect a sponge's quality unless the irregularity causes deep indentations that would make the fibre liable to tear. Nor does colour matter, for a light yellow tint is no more than the result of bleaching with permanganate of potash, which is done before the usual cleaning with dilute hydrochloric acid and hyposulphite of soda. A fine sponge that is sluggish and soggy has been badly cleaned.

How to Choose a Sponge

Buyers in shops often fancy a sample that is heavy, or else smells of brine, which last to them suggests freshness. Sponges are, therefore, sometimes loaded with silver sand to give them an appearance of having body and solidity, and the fresh ocean smell is easily provided by dipping the sponge in salt water after it has already been properly cleaned. In either case there is an added risk of the appearance of mould. Apart from softness, which, if it is desired by a buyer, can readily be told by handling, the qualities to look for are durability and absorptiveness. What matters here is texture.

A sponge that will last is tough and dense in fibre. What one would wish to do in buying is to tear it slightly, but, for obvious reasons, that is seldom possible. With a fine sponge, the fewer and smaller the holes or " eyes " in it the better, and in any case it is best to avoid several large holes set in a line, as that may encourage a sponge to tear across them. Large holes also make it drip, though in the case of a bath sponge dripping should matter but little. Again, a good specimen should take up a quantity of water and then hold it, and one can make a fair guess at its absorptiveness even when it is dry. It absorbs by capillarity, and the finer and closer its texture the more water it will pick up. It will do this quickly if it jumps back into shape after being squeezed, this springiness opening the passages so that they suck in water as does a pump.

To treat properly a sponge that is being used, it should be washed in strong soda solution, say once a fortnight. It will glut with extra quickness in hard water. It need not be put in the sun to dry, but as often as it is used it should be squeezed dry—never, on any account, wrung out—and left in an airy place. Remembering that a piece cut from a sponge too large for market size may be well worth having, and that a badly-shaped fine Turkey may have the best of textures, some reader may care for this final hint. Out of a heap of cheap sponges, such as those bought by painters, let him see if he can find one that he would use for the toilet or bath. He can handle such a collection to his heart's content. It is likely, also, that he will make some surprising discoveries.

Stone Age Man in Utah

DETAILS OF an important discovery in Utah, bearing on the early phases of the Stone Age in North America, are now available. Excavations in caves in the Great Salt Lake region, carried out by a joint expedition of the University of Utah and the Bureau of American Ethnology, have brought to light artifacts from three distinct phases of stone age culture. Not only are these all new to American archæology, but they also go some little way towards filling in the gap in the evidence, which, as recently pointed out in these columns (DISCOVERY, No. 215, p. 328), exists between the Folsom culture, the earliest known stone age culture of North America, and the Basket-makers, the prehistoric predecessors of the Pueblo Indians. Special significance attaches to this new evidence, as the cave deposits can be brought into relation with the later of two terraces formed by the shrinkage of the waters of Lake Bonneville, which in Pleistocene times covered the Great Salt Lake region and at the maximum of the final stage of the Ice Age stood at a level of 1,000 feet above the present level of the Great Salt Lake.

Three Successive Cultures

Of the three cultures, the latest, which is found in all the caves examined, had acquired the bow, and therefore is dated as not earlier than A.D. 1000. It is, however, quite distinct from the culture of the modern Shoshones of this region, and may be a relic of an early Athapascan migration from the north southward. It shows a peculiar combination of elements of northern and southern origin. The second culture, found in the Black Rock cave, belongs to a date which cannot at present be fixed more accurately than somewhere between 1000 and 5000 B.C. Its characteristic implement is a dart-point peculiarly notched, of grey or reddish quartzite. The third, and as the earliest, the most interesting to the archæologist, is a culture, also in the Black Rock cave, of which the characteristic type implement is a stone dart-point, so small as not to exceed in size a modern arrow-point. This culture is found in the lowest layers of the refuse deposits, and rests on the lacustrine gravels. In fact charcoal from the occupation level is mingled with these gravels. This indicates that man occupied the cave immediately after the recession of the waters. As the cave is some sixty feet above the lower terrace, this points to a dating of from ten to fifteen thousand years ago. The culture shows no resemblance to the Folsom culture ; but if further investigation should provide any means of correlation, this new discovery will afford the missing evidence for an exact dating of Folsom man.

The Universe in Four Dimensions

By R. H. Ayers, B.Sc.

The author presents a conception of the four-dimensional world in terms that can be understood by non-mathematicians.

IN years gone by some of our more adventurous ancestors paused to consider travel over the surface of the earth. Their thoughts seemed naturally to take them to the extremities of this surface, and the question arose: what happens when we reach the edge? However, as man is given a degree of movement in a third dimension, he soon was enabled to picture for himself the idea that the surface of the earth, although as a surface was primarily of two dimensions, could be curved in a third dimension around a globe. To-day, man with his advancing inquisitiveness considers space and wonders whether it is infinite, concludes that this cannot be, and finds difficulties in forming a conception of its boundaries. The analogy, however, readily presents itself: why not a three-dimensional space curved round in a fourth dimension? Here, a consideration of our fourth dimension seems desirable. Our sense of vision seems the best means by which to begin our study.

The Time Dimension

We look into space along a straight line, seemingly in one dimension, but we see stars whose light has taken years to reach us and we, therefore, see them as they were a corresponding number of years ago. Thus, our one-dimensional line takes on a two dimensional aspect, the second one being that of time. With our other two dimensions of space we now have the required total of four dimensions. This first conception has been rendered possible by what we suppose to be the velocity of light. Let us investigate this a little further. If we take an instant of time, the ether is in a definite condition. To us, moving in time, these conditions appear as vibrations moving with a speed of 186,000 miles per second. From this it seems reasonable to suppose that we are actually moving into the fourth dimension at this speed.

Perhaps a more conclusive way of regarding this is to imagine we travelled with the velocity of light. We should be moving along with a fixed picture of everything as it was at the instant when we started this motion. Time would stand still to us. Therefore, as the reverse is actually happening, we conclude that time must be passing with the velocity of light. We now have a measure of our fourth dimension in terms of length, *i.e.*, 1 second = 186,000 miles, and, to my mind, we cannot have a fourth dimension unless it is measurable in the units which we apply to the other three.

Our personal movement in the third dimension of space is restricted to a very thin layer above or below the surface of the earth. By the application of forces we may endeavour to extend this movement—into the sky and under the earth. The restriction in the dimension of time is even greater. No known force can act in this dimension and, therefore, we move in it at this constant speed of 186,000 miles per second. The varying "forces" acting in the three dimensions of space have wrapped surfaces round varying sized bodies. No "forces" can act in the time dimension, otherwise we could make a "time machine," and thus the curvature of space in the time dimension is definite and can result in only one four-dimensional "body," *i.e.*, one universe. Although our personal movement in the time dimension is restricted, we are not debarred from exploring this dimension. Whenever we see an object, the light has taken a certain time to reach us (using our normal expression) and it appears as it was some while ago. The more distant stars enable us to peer far into the past and with more powerful telescopes greater exploration in this dimension becomes possible.

Always at Right Angles

Our personal restriction of movement in time no doubt accounts for some difficulty in forming a conception of space curving in time and a few thoughts on this subject may be of assistance. When we look along a dimension of space we see a picture or surface at right angles to the line of vision. When we look into space we peer down the time dimension and, in whichever direction of space we look, we are looking back in time. In other words, time is a dimension at right angles to the other three, as we should suppose. People who expect to find that "the velocity of light" will vary in two opposite directions owing to our motion in space—one way our motion assisting the velocity of light and the other way opposing it—fail to realise that this movement in space is, in any direction, at right angles to the "velocity of light," which is our movement in time and thus can have no effect, as experiments prove. (Observers account for the failure of their experiments by supposing an ether drift.)

To some people astronomy seems inexact because

our vision shows us stars as they were, and they feel that we should consider the universe at one instant of time, *i.e.*, should cut out the time dimension. I prefer to consider the heavenly bodies as we see them, but with numbers against them giving their place in time starting from some zero, which will become clearer later in our study of this question. The idea of dropping the time dimension and placing everything on an equal footing in time, although erroneous, gives us some help. This would amount to a projection of a four-dimensional "body" on to a three-dimensional model—much the same as a two-dimensional shadow is cast by a solid body. We will not drop the time dimension, however, but one of the space dimensions, so that we can get a three-dimensional model which includes the time dimension. But first let us consider the bases of our model. We have our own even passage in time represented by a straight line, as in Fig. I. below.

To continue our curve we must refer to a phenomenon which is known to astronomers. When the standard lines of the spectrum are observed in the light received from the sun and from the stars, it is found that they are displaced, generally speaking, towards the red, *i.e.*, their frequency is reduced as compared with the lines seen in light from terrestrial objects. Moreover, the displacement is roughly proportional to the distance of the stars from us. This is interpreted as being due to the

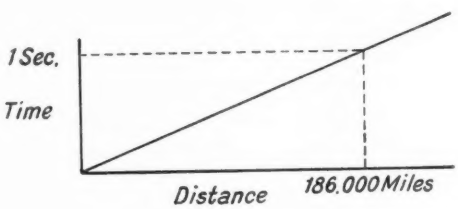


Fig. I

Doppler effect, and as a result it is thought that the distant nebulæ, etc., are receding from us with speeds which increase with the distance from us. The shift in the case of the solar spectrum is explained on the relativity theory. However, we may interpret this phenomenon as indicating that time rolls on more slowly as we leave the earth. 1 second = 186,000 miles at the earth, but elsewhere it is equivalent to a smaller distance, its actual value decreasing as we approach the bounds of the universe. Our straight line thus assumes a steeper gradient and curves round as we move into space.

The deviations from the standard law of our curve, exhibited by certain stars which have their Fraunhofer lines shifted more, or less, than we should expect or even towards the violet, are accounted for by an actual movement which gives rise to the Doppler effect and is superimposed on the general effect supposed above. A further continuation of the curve is suggested by the belief that if we go far enough into space in opposite directions we come to points which are actually close together, as in Fig. II, below.

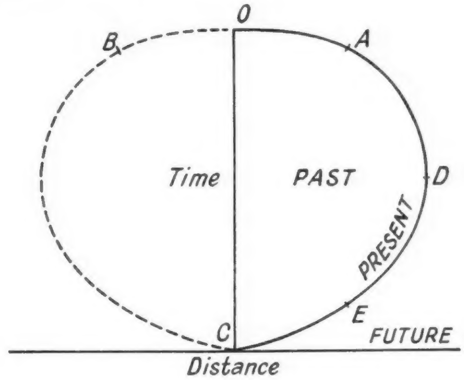


Fig. II

Point A is the point arrived at if we travel along our line of sight into space in one direction, whilst B is the point arrived at in the opposite direction. As we see, they are separated by only a short length on the distance axis. In the diagram we have naturally been reduced to two dimensions so that, in order to get our model, we must revolve our graph about the time axis, assuming that each direction in space is governed by the same law, and we get a sort of pear-shaped model. Our model now represents the universe. The *surface* of our model, if we give it its third dimension, becomes *space* curving round in time. The point C represents ourselves at the present time, and shows that we are on the boundary of the universe. This may surprise us, but we are on the line which separates the past from the future, and this is the boundary. Our curve is the division between the past and the future. It represents the present because it is the line that our vision takes us along when looking into space *now*. Although the present at any distance from us is behind us in the matter of absolute time—it is not so far down the time axis—it is nevertheless the present, *i.e.*, what we see now. Thus we can label points in the inside of our model, "past," whilst anything outside is "future." The model expands as time passes, the surface pressing into the future.

We have continued our curve so that it cuts the time axis again. Otherwise we should conclude that time had no starting point, but could go back infinitely, and our conception is designed to give us a finite universe. This

may be in effect merely making it the shape that suits us, but we shall see that there is some evidence to substantiate this shape. At the point O, where our model converges on the time axis, there was no such thing as space. The universe was a point. Now, our astronomical observations of motion of celestial bodies indicate that everything in the universe had a common starting point, which is borne out by our model.

Another conception of this point is that it is on the time axis and is, therefore, at no distance from us, *i.e.*, it is the place we are in now at some other time at the beginning of things. Moreover, it is the starting point of all other bodies as well. If the graph cuts the time axis at right angles, we see that space opened out from a point and took on finite size before time elapsed, as we should expect.

We see from our curve that a point twice as far away in space is not twice as far away in time as another point, but further. Our " velocity of light " idea gives us this false impression. This means that the linear dimension of time varies at any distance in space from our own position. As the curve bears back towards the time axis, we have a second appearance in time of a point at a certain distance. This is comparable with a journey on earth. We can take two routes in opposite directions to the same place and give it two distance values, although it is really fixed with regard to the starting point.

From the Future to the Past

Some may wonder what the interior of our model is. It represents the past and, as we cannot explore time except in space, which is the surface of our model, we cannot penetrate the interior. However, during the short course of our lives, the boundary is advanced slightly and our experience takes us from a point which is in the interior by the time we die. We may conveniently here give a conception of life in our scheme of things. Whilst unborn we are on the future side of our curve. During life we move with time and keep on the surface of our model. Then, for some reason, we fail to keep up with time and sink below the surface into the realms of the past. Some may like to think that there is some sort of existence in this realm—the interior of our model. Possibly after death there may be a degree of movement in this realm and those who believe in spiritualism may think that this movement enables those passed to reappear in the present.

Now, let us consider the universe from another angle. If we try to apply the universe, as it appears to us, to those in another position, say at E on our model, we see that certain future times appear to be " visible." This is impossible and thus we draw another picture of the universe as seen from E. E becomes the centre of the time universe, *i.e.*, comes up to point C, and we have another similar model—the universe as seen from E. Although we have had to make another model, it is still the same universe, but it looks different from another viewpoint, as we should expect. This conception also gives a limitation of space. As we can see from the model, there can be no point in the universe further from us than D.

Some may think that this conception gives no indication of the end of things. Apparently, with the enormous " radiation of energy " which is going on in the universe, astronomers predict that a time will come when energy will have reached its lowest ebb—as it has already in some of the dead stars—in the whole universe. We see from our diagram that, as our world moves in space, the linear dimension of time will vary, *i.e.*, the " velocity of light " will change. The angle at which the graph meets the time axis will vary. Supposing this angle eventually becomes zero. We shall then have ceased moving in time altogether: everything will cease moving, the world will be dead, energy will have reached its lowest ebb, and entropy its maximum.

Light Measurement

That poor lighting causes headaches is only too well known, and to the same cause can be attributed a great deal of nerve-strain, undue tiredness, and inefficiency in laboratories, offices, and factories. Investigations by scientists and public bodies have proved that ninety per cent. of people use only a fraction of the lighting necessary to the proper preservation of eyesight. It is apparent that what we have been in the habit of calling good lighting—10 or 15 foot-candles — is but a mere fraction of what the eye requires in order to function satisfactorily. The question is, how can it be found out when lighting is adequate ?

The " Avo " Light Meter is a pocket-size instrument giving direct indication of illumination in foot-candles. The meter responds to light over the whole of the visible spectrum. In its essentials it consists of a sensitive moving coil to which is connected a self-generating photo-electric cell, and it has only to be placed in the position at which the light value is to be determined for the illumination in foot-candles to be read on the scale.

As the recommended illumination for most interiors is generally between 10 and 20 foot-candles, the meter has been so designed that the scale for these lower values is very open. Consequently, although it is calibrated to a maximum of 50 foot-candles, values as low as one foot-candle can be read. A mask multiplier is provided to extend the range to 500 foot-candles, and when it is in use the reading should be multiplied by 10. The calibration is suitable for either tungsten filament or incandescent gas lighting, but it will be only approximate for other forms of illumination, though useful for measuring the relative brightness of any particular type of lighting.

MOUNT MOSOR

By F. S. Copeland

Mountaineering and cave-exploring in the Dinaric Alps.

EVERY year thousands of strangers come to visit Split, to bask and bathe, and to admire. I think that two cragsman friends of mine and I are the first party so far that went to Split with the intention to enjoy mountaineering from there. But why not? Where there are mountains there will be mountaineers. The neighbourhood of Mount Mosor, the culmination of the mountains to the south-east, is responsible for the formation in Split of the mountaineering club "Mosor," which is one of the most enterprising and enthusiastic in the land; and the prospect of Split, with its islands and sea-channels, shown in the photograph above, is one of the loveliest on the Dalmatian seaboard.

When the hospitable "Mosorashi" heard that I proposed to come to Split for a few days with Marko Debelak and Edo Deržaj, two of the best rock climbers, not only in Yugoslavia but in all the Eastern Alps, they invited us to see something of what the Kras Mountains of Split have to offer, and what the mountain lovers of Split have achieved, and arranged that we should spend a couple of days at the mountain home of the Mosor Club, the *Dom Kraljice Marije* (Queen Mary's Hostel).

There are several ways of reaching the *Dom*. The most comfortable is to secure a car and drive up to the height of about 2,000 feet by a road that follows one of the main valleys carved into the slopes of Mosor. Like a cascade of greenery, Mediterranean vegetation lines the floor of the winding valley and indicates the course of the stream that eroded it. From where the road ends beside a village, stone-built and scarcely distinguishable from the surrounding rock, a walk of some three-quarters of an hour along a mountain path leads to the hostel. Both road and path are the work of the Mosor Club. They have brought Alpine air within easy reach of an Adriatic town with its sub-tropical summers, and provided connection with the city for a number of mountain settlements that were formerly completely isolated. Another way is to reach the foot of the mountain by 'bus and then cover the rest of the distance on foot. We had experienced the amenities of the drive on a previous occasion. Now we were glad, after a spell of sedentary travel, to set our feet upon a mountain, and the long tramp was no hardship to us—all the less so, as we had an indefatigable and interesting guide and companion in Professor Girometta, naturalist and mountaineer.

Mosor, the *Mons Aureus* of the Romans, is not a single mountain, but a table-land, whose profile shows like a long ridge from below. It rises gradually from the little plain around Split and extends in a south-easterly direction for some twenty miles as far as the lower course of the Cetina river. Its width is about eight miles from the seaboard to the next inland depression. Its average height is about 4,000 feet, and it is crowned by four elevations, the loftiest of which attains about 4,200 feet. The entire range is an undulating plateau of stones, nothing but stones, a typical piece of carstic limestone. Here and there small rock faces, miniature editions of the great "walls" of the Eastern Alps, break the even line of the slope; or a solitary rock of fantastic shape stands up from the stony waste as the mast of a wreck might rise above the engulfing waves.

This arid massif is seamed with valleys and pitted

with dells (called *doline*) which are lined with clay and traversed by a trickle of water. Wherever water flows and soil accumulates, there vegetation thrives. Up to about 1,000 feet vines do well. Along the new high-road we noticed various kinds of fruit trees—cherry, plum, apple, fig, even almond trees and, of course, olive trees, which are so typical of the Dalmatian landscape. Above 2,000 feet comes the treeless zone, where plant life has to accommodate itself to long periods of drought and extremes of temperature. Harsh, dry grass, fleshy plants armed with prickles, and herbs which make up in fragrance for what they lack in colour and freshness, are characteristic of the flora among the stones. In the *doline* the vegetation is richer. Primroses, narcissi, and anemones bloom abundantly in season. Flocks of sheep find pasture and men have put up rude shelters. But water, upon which all life depends, behaves strangely in the Kras, flowing above ground or below it according to the nature of its bed. Calcareous limestone swallows it like a sieve, dolomite gives it back to the surface. I had not time to study plants as I went along, but could not fail to notice the absence of many of the ordinary Alpines, and the presence of kindred plants that had accommodated themselves to the peculiar conditions of this most weird and fascinating region.

An Alpine Hostel

Dom Kraljice Marije stands at the height of 800 metres (about 2,500 feet) above the sea, on the rim of a *dolina*. The circular valley is green and well watered, its heart and centre a dark pool shadowed by ancient willow trees. On three sides rise bare stony heights ; the fourth is open to the sea, with a view over the shore and the maze of islands stretching away to the horizon. It is a handsome building, more like a private house than an Alpine hostel. It will not accommodate as large a number of tourists as many a smaller hut in our Alps, but its rooms are spacious and airy, and good use is made of the pure and plentiful water supply from a spring near by.

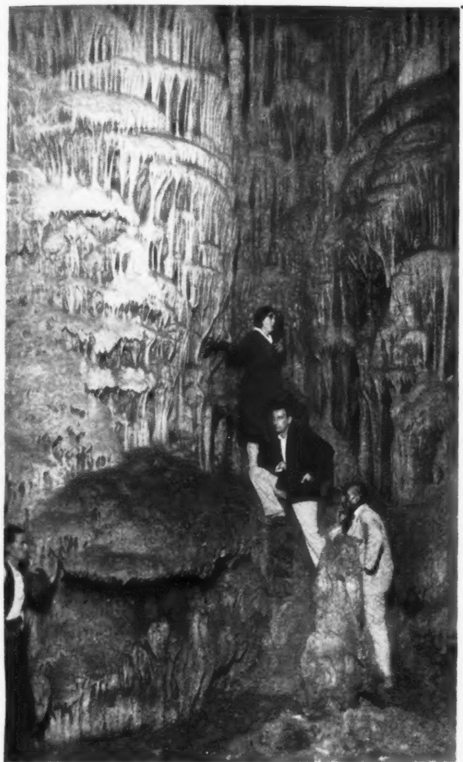
When our trio arrived with Professor Girometta, our Mosor friends were already there and at work. For the " Mosorashi " do not devote themselves exclusively to climbing. They have shouldered other more unselfish tasks in the way of cultivating the mountain they love. They plant trees that shall one day help to fight the drought that has gradually devoured the Yugoslav Adriatic littoral, ever since the original forests were felled. We were introduced to promising little squadrons of pine and oak and, nearer the hostel, to familiar Alpines and cottage garden flowers which were doing well after an exceptionally late and wet spring. On the rocks, clumps of a giant type of *Veronica* rivalled our gentians with their intense blue. Our hosts had put themselves to great trouble to give us a supper which we should enjoy. In this the Dalmatians are artists. The bill of fare was simple enough : cutlets, a salad cunningly concocted and prepared, home-made bread, and a royal wine carried up the mountain for the occasion.

Sightless Cave Dwellers

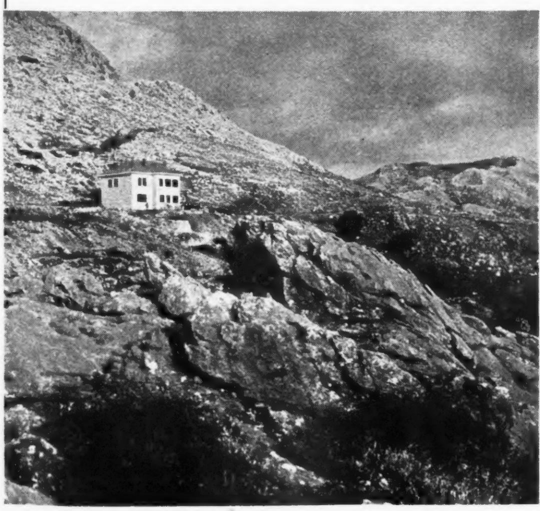
A special feature of the Kras is the number of limestone caves which may or may not be beautified with gleaming and fantastic stalagmites and stalactites, but are always interesting. At the bottom of these caves are the rivers that in other geological formations flow over the surface and irrigate the land. They are the home of a curious, diminutive fauna, grown eyeless in the eternal darkness of the underworld and compensated for the loss of sight with an inordinately keen sense of touch. Not far from the Dom Kraljice Marije is the Snežnica (Snow Pit), a deep cavern known to be the habitat of a number of rare cave creatures, all scientifically interesting. The entrance to the Snežnica is a vertical shaft, with enough hand and foothold to climb by, and a long stout rope provided for extra safety. The bottom of the shaft is 200 ft. below the surface at a point near Ljubljan, one of the highest elevations of the Mosor Range. We all climbed down and found the floor cumbered with the usual cave débris of rock. A snow slope led down to further depths which we could not explore for want of proper tackle. Professor Girometta showed my friends how to look for cave denizens, and Deržaj took to the new sport with enthusiasm. The animals—mostly beetles and spiders—which we collected were of three types, *viz.*, true cave-dwellers, eyeless and colourless ; creatures that make their home sufficiently near the orifice of the cave to have kept their eyes and the use of them ; and intruders, most of whom had probably fallen down the shaft by chance. We found excellent specimens of all three types of creature and carried them far away for our zoologically-minded friends in Ljubljana.

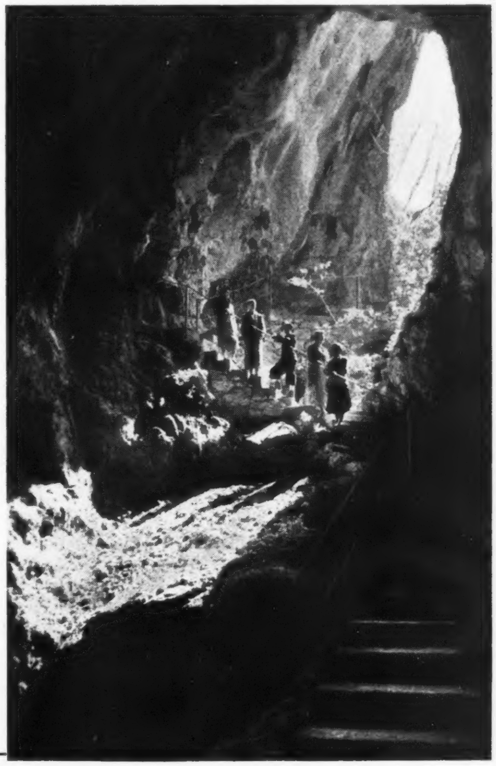
Snakes and Lizards

From the Snežnica we made our way over the width of the Mosor Range. It was a strange walk, and if the good " Mosorashi " had not levelled out a path I should have been very sorry to have had to tramp these monotonous miles of pointed stones. We kept a sharp look-out for interesting snakes, especially the vicious *poskok* (*i.e.*, the jumper) or *Vipera ammodetes*. Perhaps they overheard Marko relating how she and her brothers used to catch them in the days of their youth, for the sake of the reward which was a welcome addition to their pocket-money; because never a snake did we see through all that long summer's day. But I had the good luck



Top left and bottom right: in Vranjača Cave (above: stalactitic formation; below: at the entrance). Top right: a typical carstic limestone boulder, with the author's party on the summit. Bottom left: Dom Kraljice Marije, the clubhouse of the Mosor Mountaining Club, in typical carstic surroundings, with a 'dolina' on the right. We are indebted to Mrs. Debelak for the last two photographs.





to notice a little dark lizard which proved to be *Lacerta mosorensis*, one of the local specialities. Once we passed a spring, a true limestone spring, overarched by stone, clear, and cool as if kept on ice. After several hours of tramping we descended gradually on the eastern, landward, side of Mosor. We passed through a belt of maize fields, very small but fertile, and then came out upon the plain between the Mosor Range and the next range inland. A glance at the map will show that the Dinaric highlands are broken up into ranges running parallel to the seaboard,which are the reason, firstly, why Dalmatia has always been so entirely separate from neighbouring Bosnia; and, secondly, why she enjoys her Mediterranean maritime climate with its advantages over the continental climate of the interior.

In the hillside at the foot of the mountain is one of the most beautiful and interesting of the natural phenomena near Split. This is the Vranjača Limestone Grotto, about eighteen miles by good road from Split. The Vranjača should become as famous as it is beautiful, so that there may be a regular 'bus service between Split and the grotto. Concrete steps lead down to the depths; ledges and galleries are provided with handrails, all the work of the Mosor Club, as is also the electric light that illuminates its wealth of magnificent limestone formations—pillars, curtains, "icicles"—not a whit less astounding than those of Postumia.

We had hoped to catch a train at a country station not too far from Vranjača, but missed it. Our Split friends looked blank. We had tramped from early morning; it was near sundown, and we had still some fourteen miles to cover, one way or another. I don't know who was the genius who suggested that we had better debate this problem over a glass of good Dalmatian wine at an inn, instead of on the dry and dusty highroad. At the inn we managed to compound with the driver of what in Scotland used to be called "a machine," *i.e.*, a horse-drawn vehicle, otherwise unspecified, to give us a lift as far as Klis, the romantically situated village and splendid ruin at the head of the pass that leads inland from Split.

We did not save much time thereby, but we certainly gave our legs a welcome rest. From Klis we looked down upon a sea of twinkling lights which was Split. Above us, the stars were great and burning—stars of a southern sky. At last, at Solin of the ruins, we struck a 'bus. And with that our Dinaric mountaineering expedition was over.

The rest of our stay at Split was occupied in farewells and in haunting Professor Girometta's little zoo and marine aquarium in the Marjan Park. The professor very kindly presented us with a *poskok* for a Ljubljana snake specialist, and the poor beast cannot have felt very happy in the small tin in which it was packed. My lizard and our other finds were already in spirits. We had been most lucky in our captures; the specimens were, in due time, beautifully mounted, and the small collection now looks quite impressive in the cabinets of the Zoological Institute of the University of Ljubljana.

Scientific Apparatus, Chemicals and Reagents

The above is the title of the 25th edition of Townson and Mercer's (34, Camomile Street, London, E.C.3) comprehensive catalogue of 1,314 pages. The subjects covered include assaying, bacteriology, botany, chemistry, clinical diagnosis, entomology, meteorology, metallurgy, mineralogy, pathology, physiology, serology, etc. In addition a complete range of apparatus and materials for industrial purposes, for analysis, and for the general equipment of research laboratories in every department of science, is included.

The catalogue forms an excellent volume, well bound and fully illustrated. Sections are provided so that a ready reference is possible, while special types of apparatus have a complete index of 28 pages for rapid and convenient reference. Some of the very latest apparatus is listed and it would be futile to pick out any in particular. Technical and research workers engaged in various industrial undertakings will find all the necessary instruments and materials here at hand and if special apparatus is not given it can be made to specification. Industrial chemists engaged in the testing of oil and tar will find a fully illustrated series of apparatus.

So vast a field, however, is covered by the volume that it is impossible to describe it adequately. For instance, there are 56 pages, profusely illustrated, dealing with standard physiological apparatus. One very welcome feature is that all the items given are priced and, although in some instances market fluctuations might affect certain goods, a general idea of their approximate value can be readily assessed.

A good range of books is also given—pp. 1205-1212—all of which are obtainable from Townson and Mercer. These are classified under the following subjects: anatomy; bacteriology; biology; bio-chemistry and physiological chemistry; botany; general chemistry, industrial chemistry, organic chemistry, physical chemistry; general science; histology; hygiene and public health; materia-medica and pharmacology; oils, paint, and tar; pathology; physiology; psychology. Such a list is highly representative and will prove of great assistance to both the student and research-worker.

FRANK W. BRITTON.

The March of Knowledge

Wetter Water

One of the newest derivatives of petroleum to become valuable is a material to make water wetter. If soap is dissolved in water it has power to wet more different kinds of materials than plain water, and is therefore, in a sense, wetter. Modern industry, particularly textile, has used many different materials to help soap " wet " water. The latest is being made from petroleum, in which the molecules are broken too small for use in motor spirit, by the cracking process.

New Robot Phone

A patent has been granted in the U.S.A. on a telephone switchboard system that does everything except prevent the subscriber from calling a wrong number. The new system automatically repeats calls until an answer is obtained either when the line is busy or there is no answer, keeps a record of the length of the call, and automatically makes out telephone bills. Unlike the ordinary dial telephone, on which a caller dials the desired number and then waits to hear whether the line is clear, the user of the new system dials the number and hangs up. When there is an answer, the machine rings his telephone.

Syllabary for Eskimos

Included in the varied cargo taken north aboard the R.M.S. *Nascopie* by this year's Eastern Arctic Patrol were 4,000 sets of the syllabary to be distributed to the Eskimos at every port of call. These were the gift of R. P. Isbister, of Hamilton, Ontario, and were welcomed by the natives, who are being taught to read and write in the syllable characters. Originally designed for the Cree Indians, the syllabarium makes use of some sixty phonetic characters, and it has been found simpler to form Eskimo words by the use of these characters than by the English alphabet, which often makes their words cumbersomely long.

Selling Snakes

One of the queerest livelihoods in Europe is that earned by men, women and children in the stony, barren " karst " districts of Hercegovina, North-West Jugoslavia. These Balkan peasants depend for a living on poisonous snakes. They spend their time searching for the giant viper—the fatal " poskok " of the karst mountains—in the woods. For each live snake, with the poison glands intact, they receive the equivalent of two shillings, from the agents of a German chemical concern at Siroki Brijeg, Hercegovina. Catching the deadly giant vipers alive is a dangerous and expert job which the peasant boys learn from early childhood. With a cleft stick, they pinion the snakes' necks or capture them in curious, long scissor-shaped traps, like mole-traps. The snakes are shipped alive in special boxes to Germany, where their poison is extracted by vaccine manufacturers, who use it as an anti-snake bite serum, sold to hospitals and medical men in the tropics. Without this snake-poison industry the peasants of the barren karst crags of Hercegovina would have to starve or emigrate.

Books Received

Wide Horizons. By R. H. Croll. (Angus & Robertson, 9*s.* 6*d.*)
Under the Pole Star. By A. R. Glen and N. A. C. Croft. (Methuen, 25*s.*)
A Nature Lover in British Columbia. By H. J. Parham. (Witherby, 8*s.* 6*d.*)
The Inner Gate. By E. H. Carrier. (Christophers, 3*s.* 6*d.*)
Alternating Current Electrical Engineering. By Philip Kemp. (Macmillan, 5th Ed., 15*s.*)
Physical Chemistry. By J. N. Bronsted. (Heinemann, 12*s.* 6*d.*)
The Science of Seeing. By M. Luckiesh and F. K. Moss. (Macmillan, 25*s.*)
The Principles of Mathematics. By Bertrand Russell. (Allen & Unwin, 18*s.*)
Sunspots and their Effects. By H. T. Stetson. (McGraw-Hill, 8*s.* 6*d.*)
World Natural History. By E. G. Boulenger. (Batsford, 7*s.* 6*d.*)
Biology for Senior Schools : Book I. By M. R. Lambert. (Macmillan, 3*s.* 6*d.*)
Types of Open-Field Parishes in the Midlands (Historical Assoc. Pamphlet). By F. G. Emmison. (Bell, 1*s.*)

Correspondence

To the Editor of Discovery.

Sir,—A line has been accidentally omitted from the last paragraph of my letter in Discovery for December. The paragraph should have read :—

" As to the food factor in migration, what is most important is the availability of food, both in quality and quantity, for the nestlings and fledglings, rather than for adults."

Yours faithfully,

Porlock, Somerset. E. W. Hendy.

Science Note !

From the shores of Cyprus, the gluttons of the air, Peccifiers (*sic*), are being featured in a London hotel for, I believe, the first time. The birds are said to be easily caught by the Cyprists (*sic*) because they stuff themselves so full of figs that they cannot fly. Afterwards they are pickled in spices till the bones are as soft as the flesh and equally edible. (*From a weekly trade paper.*)

Practical Zoological Illustrations (*Part I.—Vertebrates*), by S. Lockyer and D. R. Crofts (Macmillan, 10*s.* 6*d.*), consists of 28 cards ($14\frac{1}{2}'' \times 9\frac{1}{2}''$) in a portfolio and are accompanied by a cellophane envelope (1*s.*) to take one card. They are intended, not to replace laboratory work, but to help students to perform detailed dissections of their own. Text-book illustrations often fail in this respect because, being diagrammatic, they do not resemble the dissection as actually seen by the worker. It is hoped that these illustrations will answer the purpose of verbal descriptions, and will also save a good deal of the students' time.

The Pyramid-Temple of Kukulcan

From a Special Correspondent

The Carnegie Institution of Washington has long been studying the ruins of Maya origin in Middle America. Among the sites to which it has devoted attention, that of Chichen Itza, once the metropolis of the Maya of Yucatan, has proved unusually fruitful, especially in information about that period of Maya culture immediately preceding the coming of the Spaniards. The Institution here presents an account of a recent investigation, made in close and friendly association with representatives of the Bureau of Pre-Hispanic Monuments of the Mexican Government, which yielded specially important results.

DURING the summer of 1936, archæologists of the Mexican Government, working at the Maya ruins of Chichen Itzá, Yucatan, made an extremely important discovery. They found that El Castillo, the most impressively dominant of the pyramid-temples of the famous site, embraced within itself an older pyramid-temple that has been completely concealed for centuries. When the chambers of this inner temple had been cleared objects were revealed of the utmost value to the scientists who are trying to clear up the perplexities that have arisen respecting the Maya race, the greatest of all the pre-Columbian races of the New World.

El Castillo, built to honour Kukulcan, one of the members of the Maya pantheon of gods, stands near the centre of a 45-acre terrace of rubble masonry raised a few metres above the level of the vast limestone plain of northern Yucatan. Surrounding the pyramid lies a complicated agglomeration of temples, courts, arcades, colonnades, palaces, and mounds not yet excavated—an architectural complex so extensive, indeed, as to indicate that Chichen Itzá, when at the height of its development, must have presented an amazing spectacle.

The Jaguar Throne found in an inner chamber of the buried temple. It is carved from a single block of stone, and was painted a vivid red and studded with inlaid discs of green jade. The turquoise plaque on the seat is illustrated overleaf.

The peak of activity at Chichen Itzá was reached during the New Empire period of Maya history, a period which probably began soon after the middle of the 11th century and which continued well into the last half of the 15th century, almost to the time of the coming of Columbus. This period is often referred to as the period of the Maya renaissance, and it is indeed true that during this time Maya culture experienced a sharp revival which found its most fruitful expression in the designing and constructing of great buildings for religious and ceremonial purposes.

This awakening to exuberant architectural activity appears to have been due, in part at least, to the influx of an alien people from the west. There is uncertainty as to just who these people were but there are grounds for believing that they belonged to the great Nahuan linguistic group of Mexico. At all events they profoundly affected the art, the architecture, and the religious and ceremonial life of Chichen Itzá, Mayapan, and Uxmal, the three city-states of Yucatan that, during this period of Maya history, formed the political confederacy known as the League of Mayapan.

The invaders from the west brought with them, for example, worship of Kukulcan, the

The north face of El Castillo as it now appears, after the restoration carried out by the Mexican Bureau of Pre-Hispanic Monuments.

feathered-serpent god, represented by a rattlesnake having a body whose scales were replaced by the feathers of the sacred quetzal and from whose mouth a human head frequently protruded. Everywhere in Chichen Itzá among the buildings of the New Empire period, representations of this all-powerful divinity of the earth and sky are to be found, employed with unrestrained prodigality.

So, too, the immigrants from the west seem to have been responsible for a marked increase in human sacrifices. Indeed, it is thought by some that they are rightly to be charged with having introduced the religious ceremonies that were associated with El Castillo and the sacred well nearby—ceremonies which culminated in the casting of the most beautiful of the Maya maidens into the well in a supreme effort to appease the rain-god who was thought to have his abode in the depths below.

Sr. Ignacio Marquina, chief of the Bureau of Pre-Hispanic Monuments of the Mexican Government, points out that the older Maya buildings, those antedating the New Empire period, were characterised by narrow halls which were roofed by means of the typical corbel arch of the Maya. On the other hand, the structures which were characteristic of the Nahuan peoples consisted of halls and rooms of large dimensions, roofed by wooden frameworks supported by pillars and beams. Clashing of the two types at Chichen Itzá produced structures, Sr. Marquina observes, wherein the halls, huge rooms, and pillars of the second type were combined with the corbel-vaulted roofs of the first type, which, however, were supported by wooden beams resting upon pillars.

The north face of El Castillo before restoration. From a photograph taken by H. A. Sweet on the Maudslay Expedition of 1889.

According to Dr. H. E. D. Pollock of the Carnegie Institution staff, who has made a close study of Maya architecture, a distinctive characteristic also of the new architecture which developed during this period was the emphasis placed on stone in contrast to stucco as a decorative medium. The split column was also extremely popular, and geometric patterns, worked out in stone mosaic, were in constant use.

Dr. Pollock adds that employment of the column inside buildings as a roof support (mentioned by Sr. Marquina) produced extraordinary changes in architectural design. In

consequence, great colonnades, consisting of row upon row of round or square columns, and roofed either by vaults or relatively light flat ceilings, came into existence.

So, too, the use of serpent columns in doorways was a notable development in decoration. The mask continues but undergoes considerable change in treatment. Sculpture in the round is also quite different, as seen in the Atlantean figures that served to support the temple altars. A wealth of bas-relief, quite distinct from the earlier types, and often showing evidence of having been brightly painted, is likewise characteristic of this period. A number of fragments of wall painting have been preserved which had been done in vivid colours, and, as Pollock says, although the composition is rather naïve, great clarity is expressed and often considerable spirit.

Such was the period of the New Empire among the Maya of Yucatan—a period during which the culture of this extraordinary race came into its final flowering. It was early in the period and in response to the renovating and rejuvenating tide of new life that flowed into Chichen Itzá, that El Castillo, the pyramid-temple of the great god Kukulcan, was erected. Abandoned soon after the coming of the Spaniards, Chichen Itzá and its magnificent structures quickly fell prey to the jungle. Indeed, the whole of this great Middle American civilisation dropped out of human consciousness, and became lost to human view.

True, Diego de Landa of the Spanish Franciscans, who went to Yucatan in 1549 as a missionary, and who, in 1573, became Bishop of Yucatan, described the people and the ruins of Yucatan with considerable detail in a manuscript entitled *Relacion de las Cosas de Yucatan ;* but this manuscript lay unknown in a library in Madrid for nearly three hundred years before it was discovered and published.

In point of fact, existence of the remains of this great pre-Columbian civilisation remained practically unknown until 1841, when it was brought to the attention of the modern world by John L. Stephens, the American diplomat-explorer.

The Maudslay Expedition

Although Stephens described many of the important ruins at Chichen Itzá, including the great pyramid, and Catherwood, the English artist who accompanied him, made excellent drawings of a number, it remained for Alfred P. Maudslay, an English explorer and archæologist, to be the first to apply modern scientific methods to their study. In 1889 he spent six months at Chichen Itzá, working continuously amid the ruins, clearing away the bush, surveying and mapping the principal structures, taking photographs wherever possible, and making papier-maché mouldings of the sculpture.

Although Maudslay cleared the bush from many of the ruins, he made no attempt to restore any of them or to preserve them from further collapse and disintegration. The first step towards their protection was taken in 1911, when the Mexican Government appointed caretakers to Chichen Itzá. However, little work was done on it until 1916, when Dr. Manuel Gamio, then Director of Anthropology of the Mexican Government, realising that the temple surmounting El Castillo was in imminent danger of collapse, had it strengthened at critical points with concrete. In 1925 a Department of Monuments within the Ministry of Public Education was established by the Mexican Government and responsibility for supervision of the ruins in Chichen Itzá vested in one of its bureaux, that of Pre-Hispanic Monuments. Of this bureau, Sr. Ignacio Marquina has been the head for several years.

El Castillo Restored

The restoration of El Castillo, so far as it could be carried with assurance that the original design was being faithfully followed, was completed in 1927. To give an idea of the state of the pyramid-temple before repair, one of its sides, the south side, has been left as it was. The Stephens and Maudslay pictures show how disastrous had been the effect wrought by the forces of nature and by the inhabitants of neighbouring villages as well, who had removed much of the original facing for use in their own constructions. Comparison of the picture of the restored structure with these earlier ones will give some idea of the magnitude of the task undertaken by the Bureau of Pre-Hispanic Monuments and also how well that task was performed.

Meanwhile, the Mexican Government entered into contract with the Carnegie Institution of Washington, whereby the Institution was permitted to conduct archæological studies at the ruins of Chichen Itzá. In 1925 the Institution staff began excavating a tree-covered mound of debris near El Castillo. As fallen elements were identified and restored to original positions, this structure, called the Temple of the Warriors, grew into one of the finest examples of New Empire construction so far found in the entire Maya area.

In 1926, Earl Morris, in charge of the work at the temple, made a discovery about the way in which the pyramidal foundation had been constructed that suggested a new field of investigation which archæologists have been quick to follow up. He had almost completed work on this structure when a sculptured column block projecting from a corner of the supporting

pyramid suggested that some exploratory excavation of the pyramid itself should be undertaken. As a result of the investigation which he made it was found that chambers existed belonging to an earlier temple and that they had been filled with rubble and had been incorporated, in their entirety, in the pyramidal base of the Warriors' Temple. Morris dug out the filling, shored up the walls with concrete piers to prevent collapse, and drove shafts to surface for air and light and easy access. In course of this work many features were revealed which have thrown important light upon the stage which Maya culture had reached when this early temple was erected.

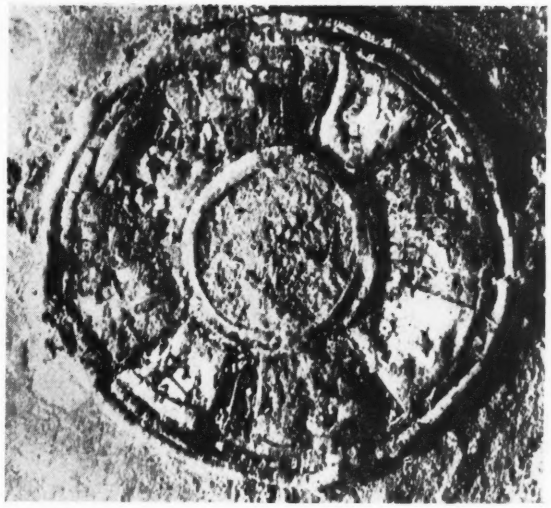
Discovery that the pyramid builders of the Warriors' Temple, instead of completely demolishing the older structure, had preserved a substantial portion of it by filling it up and covering it over, suggested that a similar practice might have been followed in the erection of other Maya pyramids. And this has proved to have been the case.

In 1936, archæologists of the Mexican Government, on completing exploration of El Castillo, added another conspicuous example to the growing list of treasure-yielding pyramids, as we shall see.

The Hidden Temple

Exploratory work on this great pyramid to determine what, if anything, lay concealed within it, was begun in 1930 under direction of Sr. Marquina. The first step taken was that of driving a tunnel at ground level straight in from a point at the centre of the south face of the pyramid. Thirty feet within, the base of an earlier pyramid was encountered, whereupon the tunnel was turned to the left, or west, and driven along the base line of the hidden pyramid to the latter's south-west corner. Turning the corner, the tunnel was continued northward along the western side of the inner pyramid to a point far enough past the centre to prove that no stairway existed on the west face of the inner structure. Next, the attack was shifted to the north face of El Castillo and at a point at the base line just west of the stairway, selected to avoid damaging the stairway, a tunnel was run east until it was under the centre of the stairway, then it was turned to the right and driven south towards the heart of the pyramid. Here, again, at a distance of about 30 feet, the base of the older pyramid was reached a second time, but, unlike their experience with the tunnel at the south face, the investigators encountered a stairway, apparently leading up the north face of the buried pyramid.

At foot of the newly discovered stairway they came upon a rectangular limestone box, approximately



The turquoise mosaic plaque from the seat of the Jaguar Throne.

$2\frac{1}{2}$ feet long, 2 feet wide, and 2 feet deep. Its lid consisted of a single stone slab which had been fitted to the opening.

Outside the box lay the skeleton of a man. When the ponderous lid was raised, to the delight of the archæologists there were revealed: two turquoise mosaic plaques; three necklaces, one of coral, one of turquoise, and one of jade; seven heads of jade; five jade pendants, one of which was an exquisitely carved, iridescent piece representing the figure of Itzamná, the head of the Maya pantheon; a piece of jade with a fragment of cloth attached; about 2,000 loose button-shaped beads of turquoise; and two unusually large sacrificial knife-blades of flint, four inches wide and more than a foot long.

Dr. Sylvanus G. Morley of the Carnegie Institution staff, who examined the box and its contents soon after discovery, believes that it is to be regarded as a ceremonial deposit made on the occasion of beginning work on the new pyramid—a procedure suggesting the modern practice of laying corner stones and of depositing within them or under them boxes containing objects of probable interest to future antiquarians.

A year or so after discovery of the inner stairway, Sr. Marquina and his colleagues began sinking test pits in the platform at top of El Castillo to see if the inner pyramid was surmounted by a temple structure. They soon found that such a structure existed; that it had been filled in instead of having been demolished; and that its top lay only about a metre below the floor of the outer temple. Tunnels revealed that the temple surmounting the earlier pyramid contained two

chambers, one directly behind the other, and that entrance was gained through a single doorway on the north side, reached by the stairway running up the north face of the inner pyramid.

During 1935 the outer chamber of the older buried temple was cleared of its rubble filling. At the centre of this chamber a stone statue was discovered which represented a recumbent human figure (the so-called Chac Mool figure) of which ten others have been recovered in Chichen Itzá. These figures are generally found in front of temple entrances at the head of the approaching stairway. Usually a stone disc rests upon the abdomen of the figure, on which offerings were probably placed by worshippers entering the temple. Occasionally, instead of a disc, the abdomen of the figure is hollowed out, cup-shaped.

Unlike all other statues of this type so far found, the ten toe-nails of this one, made of highly polished white bone, were still intact. Both its upper and lower teeth, made of the same material, were in position, as were its eyes, which also were made of white bone. To represent the pupils of the eyes, circular pieces had been cut from the centres and replaced with a black bituminous material.

The Jaguar Throne

During July and August, 1936, the excavation of the inner chamber was pushed to completion and an amazing discovery made. The back wall of the chamber was found to have been studded at regular intervals with the heads of human femurs, presumably obtained from sacrificial victims. In the centre of the chamber stood a box of squared limestone blocks, covered by two ponderous flat stone slabs. Inside this was a throne fashioned from a single block of stone, carved to represent the figure of a jaguar, and painted a vivid red. As the figure has been shielded within the pyramid all these centuries from the light the colour is probably almost as brilliant as when it was new. The spots of the jaguar are represented by inlays of apple-green jade. The eyes also are made of jade, unusually large hemispherical pieces of excellent quality having been used for the purpose. The teeth and fangs appear to consist of hard white stone. The statue stands $2\frac{3}{4}$ feet high. On the jaguar seat lay a mosaic turquoise plaque similar to the two found in the box at the foot of the stairway. On top of the plaque reposed a shell necklace, and a jade pendant carved to represent a human face.

Dr. Morley is of the opinion that the central object of the inner chamber may properly be identified as a jaguar throne. He points out, in support of this opinion, that double-headed jaguar thrones have been found in the ruins of Uxmal; and that representations of it are to be found in the Temple of the Warriors at Palenque, and at Piedras Negras, Guatemala.

The jaguar once occupied a wide area, ranging from Texas through Central and South America to Patagonia. It is still to be found in the Maya regions of Middle America, where its typical colouration is a rich tan upon head, neck and body, marked except towards the end of the tail, which is ringed, with black spots arranged in rosettes with a black spot in the centre. It is a thick-set animal and does not stand high upon its legs; but it is agile and its movements are very rapid.

Warrior Cults

Ralph L. Roys, who, under the auspices of Carnegie Institution, has recently translated one of the sacred books of the Maya of Yucatan into English, states that although the jaguar appears in the Maya art that antedated the Nahuan influx, it was then always associated with the priesthood: whereas, after Yucatan came under domination of the alien invaders from the west, the figure of the jaguar was used symbolically by the warrior class. It is not improbable, therefore, that figures of the jaguar, the eagle, and other animals as well, were employed by the warrior cults or societies of Yucatan very much as insignia are used by various orders of modern times to identify particular groups. Neither is it improbable that the older temple buried within the pyramidal base of El Castillo was erected by the jaguar cult of warriors and used by them in ceremonial practices.

Although the contents of the box found at the foot of the inner stairway of El Castillo have been taken to the Museum of Archæology and History at Mérida, the capital of the State of Yucatan, for safe keeping, very wisely the Mexican authorities have decided not to remove the reclining human figure and the jaguar throne, with its turquoise mosaic plaque, from the chambers of the inner temple. Instead, they have covered them with protective varnish, glassed in the jaguar throne, and installed artificial light.

It is therefore now possible for visitors to enter the tunnel at the base of the north face of El Castillo, to follow through to the foot of the inner stairway where the ceremonial box reposes, to ascend to the summit of the buried pyramid and thence, through the portal of the hidden temple, to enter its age-old throne room, and there witness in imagination the barbaric scenes that once took place in this sacred enclosure and to view in actuality what Dr. Morley has characterised as the most spectacular discovery of archæological specimens *in situ* ever made in the New World.

A Discoverer of the North-West Passage

By Colin Johnston Robb

Little enough is known of Sir John Franklin's companions on his ill-fated Arctic expedition. Mr. Robb, being a relative of Captain Crozier, is enabled to throw some interesting light on the career of the second-in-command, who was in charge of the expedition after Franklin's death, until the bitter end.

It may safely be asserted that the subject of this article is something less, even, than a name to the great majority of the British public to-day, yet the name of Francis Rawdon Moira Crozier should rank among the highest in the field of discovery. Captain Crozier was born in Banbridge, Co. Down, in September, 1796, being the tenth child of George Crozier, Attorney-at-Law. He was named after Francis Rawdon, Earl of Moira, a soldier and diplomat of great prominence and distinction in his time.

Captain Francis Crozier, R.N., F.R.S., F.R.A.S.

Crozier's ancestors were an old border family, who settled at Stramore, a few miles west of Banbridge, in 1692. Attorney Crozier was not rich: he was not poor. The children were brought up in comfort but with simple, frugal tastes. Mrs. Crozier, the mother of the Arctic officer, was a handsome, clever woman, clear-minded, strong-willed; a real spartan in her way. Young Crozier's education began under a capable governess. He was a handsome, bright-eyed, serious-looking lad, gentle as a rule, but sometimes defiant. At the age of ten he had a quarrel with his mother and ran away, concealing himself on a yarn loft for two days without food. He finished his education on shore at the age of fourteen and entered the naval service on board H.M.S. *Hamadryad*, joining H.M.S. *Britain* as midshipman in 1812.

Crozier was appointed to H.M.S. *Fury* in 1821, and accompanied Sir W. E. Parry on one of his strenuous adventures to the Arctic; and in 1826 he was promoted Lieutenant. During Parry's attempt to reach the North Pole on sledges, Crozier made some interesting magnetic and astronomical observations, when the heights of Spitsbergen were sighted in May, 1827.

When H.M.S. *Cove* sailed to the assistance of whaling ships beset with ice in Davis Strait, under the command of Captain Sir James Clark Ross, Crozier was appointed an officer of that ship, and on his return home in 1837, was promoted to the rank of Commander for his scientific researches and able seamanship. He again served as second-in-command under Ross in the Antarctic Expedition of 1839, which was undertaken on the recommendation of the Royal Society and the British Association for the purpose of scientific research and geographical discovery. During this hazardous voyage he received the well-earned reward of Post rank. It will be recalled that this expedition got within 160 miles of the South Magnetic Pole, while a Cape at the foot of Mount Terror was named Cape Crozier after the subject of this article.

In the spring of 1845 a big venture of discovery, in quest of the long-sought North-West Passage, was undertaken by the Government for the purpose of making magnetic, geographical, and other scientific observations. By this time Crozier had made the lasting friendship of Sir John Franklin, and when Lord Haddington, First Lord of the Admiralty, privately offered him the supreme command, he declined the offer in favour of Franklin, who was the most senior Arctic officer then alive. He accepted the post of second-in-command and two vessels were chosen for the expedition, the *Erebus* and the *Terror*. Commander James Fitzjames, an able officer, was appointed to take charge of magnetic observations, and the eminent naturalist, Dr. Goodsir, was placed in charge of biological and other observations.

Each vessel had a complement of 67 officers and men and stores for three years. The ships were fitted with screw propellers and auxiliary engines, capable of developing about twenty horse-power. Every human precaution was taken in order to ensure success and a safe homecoming, the vessels being well adapted to the services required of them, and both Franklin and Crozier were veterans in Arctic exploration. The expedition sailed on the 19th of May, 1845, from Greenhithe, and was last seen by a whaler in Baffin Bay,

where the last call, "All well," was received from the adventurers, on the 26th of July of that year, as they sailed into the unknown. They spent that winter on Beechey Island, in Barrow Strait.

For years not a word was heard of the bold and intrepid discoverers, uneasiness amounting to certainty of calamity being in the minds of the public. The Government offered £20,000 to any party that should render assistance to the doomed expedition and £10,000 for authoritative information of its fate. Some twenty rescue parties sailed forth to assist in the quest, but all was unavailing, until 1853, when Dr. John Rae, an officer of the Hudson's Bay Company, discovered relics of the ill-fated expedition in the possession of the Eskimos, among them a silver spoon bearing Crozier's crest. The story of Sir Leopold McClintock's expedition of 1857 and his discovery of documents proving the death of Franklin is too well known to be repeated here.

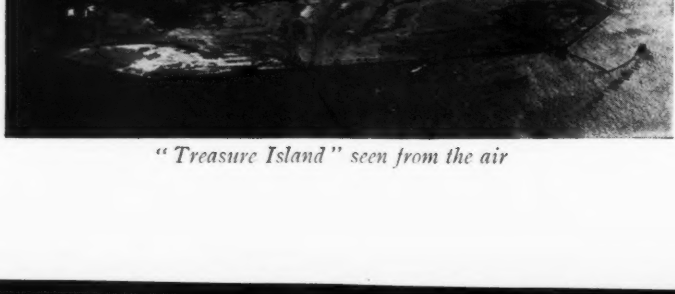
After Franklin's death in June, 1847, Crozier succeeded to the supreme command of the band of discoverers, who were the first to prove a continuous waterway between the North Atlantic and Pacific—the long sought North-West Passage. Crozier and Fitzjames, the second in rank after the death of Franklin, found themselves surrounded by grave perils. Their ships being ice-bound in Victoria Strait, whither they had drifted, they decided to abandon them and seek for succour from the mainland, by way of the Great Fish River to Fort Churchill. Their dead chief had, however, warned them of the dangers of land travel during the winter months, as game was not to be procured and the chance of meeting Eskimo was practically non-existent. After reviewing the situation they deemed it necessary to spend another painful winter in the ships, with the hope that spring might release them.

On April 22nd, 1848, Crozier and his men landed on the north-west shore of King William Island 69° 38′ N. lat. and 98° 41′ W. long., and on the 26th of that month they began their forlorn journey southwards along the western coastline of the island. In July, 1848, the Eskimos saw Crozier and his party on the southern seaboard of the island—the last time they were seen—and from there they journeyed to Todd Island and later landed at Starvation Cove on the north-east shore of the Adelaide Peninsula, on their way to the Great Fish River, whither they were going for relief. But winter came upon them when they were worn out, half starved, suffering from many ills of the flesh and practically out of provisions.

How terrible must have been the last days of Crozier and his band, their eyes straining towards the distant horizon in the vain hope of succour, a hope that was never realised. At some unknown spot far away on the icy wastes of the Adelaide Peninsula rests all that is mortal of Captain Francis Rawdon Moira Crozier, the little known Arctic officer, a discoverer of the North-West Passage.

New Island for America

Four hundred acres of new territory have been added to the territory of the United States with the completion of "Treasure Island" in San Francisco Bay. This man-made island will be the site of the 1939 Golden Gate International Exposition. Formal delivery of the island by the U.S. Army Corps of Engineers, who were responsible for this 400-acre reclamation project, was made on November 21. One of the features of the exhibition will be British Empire Day, May 27. Situated between the world's two greatest bridges, the site of the exhibition is itself an outstanding accomplishment. Twenty million cubic yards of filling have been placed within the 17,760-foot sea-wall, and building construction is already under way. Two immense concrete and steel hangars, measuring 287 by 335 feet each, have been completed, and a three-storey air-terminal building is nearing completion at a cost of $1,000,000. When the temporary exhibits are swept away, the hangars and terminal will form the nucleus of a new San Francisco municipal air port, within ten minutes' drive of the city.



"Treasure Island" seen from the air

Pigment of Caterpillars

By Herbert Mace

Unlike the majority of insect larvæ, caterpillars are notable for their striking colours. Our article shows why this is so, and explains the many remarkable variations from the usual green colour.

INSECTS present a peculiarly complicated problem in connection with the evolution of colour, because, instead of developing gradually from infancy to maturity, they pass through four distinct stages of life, each separated by a more or less sharp line of division. Whereas, in the case of mammals and birds, the immature stages are passed under parental protection, most insects live an entirely independent existence from the beginning. Once the fly, the beetle, or the butterfly has laid its eggs, they must work out their own salvation and adjust themselves to the changes and chances of life.

The duration of each stage of a butterfly's life is most variable. The egg laid in summer may hatch in a few days, or remain dormant for months. The High Brown Fritillary starts in August as an egg which does not hatch till the following March, so that three-fourths of its life are passed in this form. In other cases the caterpillar stage is longer, though often a large part of this is dormant. Several butterflies related to the one mentioned leave the egg in a fortnight, but after one light meal, the little caterpillars retire into premature hibernation and remain dormant for six months. Others feed and grow rapidly and soon enter the pupal stage, which endures for many months, while in others all the preparatory stages are passed in five or six weeks, and the final winged stage is the longest. There is no rule, even within the limits of a genus, and it would be interesting, but foreign to my present purpose, to consider the reasons for this variation.

The Life of the Egg

Comparatively little attention has been paid to insect eggs, but there is no doubt that careful study would reveal many interesting facts about their production and distribution. From Mr. Frohawk's great book about the 62 British diurnal butterflies, I have compiled some figures which will at least indicate that this is by no means a trifling and simple subject. Of this number nine spend the winter as eggs, being from seven to nine months in this state. The rest hatch in periods varying from three days to six weeks. The period is fairly constant for each species, but in two or three species there is a long range. The egg of the Adonis Blue may hatch in 14 days or not for six weeks. An average of all the species works out at 12½ days, and the greater number leave the egg between seven and fifteen days from its deposition.

Only ten species lay their eggs in clusters. The Peacock is most careless, putting the whole of her eggs (about 500) in one confused heap: others make several patches varying in number. Three lay their eggs in a long row, no less than 46 lay them singly on the food plant, while two only, the Marbled White and the Ringlet—both grass feeders—drop them in the grass, so that they fall to the ground. All but eight put their eggs actually on the food, five deposit for the winter on twigs near the buds and three put them in crevices in the bark of trees. An outstanding example is that of the Silver-washed Fritillary, who put her eggs on the trunk of a tree near the food-plant (dog violet). They are not close to the ground, but some feet up the trunk, and although the caterpillars hatch in a fortnight, they eat only the egg-shell and then hibernate till spring. Of the majority which oviposit on the food, seven lay on flower buds, and the rest on leaves, and of these 17 always put the egg under the leaf, 25 seem indifferent and only three invariably deposit on the upper side of the leaf.

Moults and Colour-changes

Generally speaking, there is sufficient harmony between the colour of the egg and that of the food-plant to make it not at all easy to distinguish and, since the egg does not betray itself by movement, no very exact approximation is necessary. When, however, the young caterpillar appears, it is a moving creature and more readily seen. Usually, it begins to eat and grow at once. Sometimes its general appearance does not alter much till it passes into the pupal form, but there is often a complete change of colour and marking at one or more of the regular moults to which it is subject. Each of these changes is related to some alteration, though it may be only slight, in the creature's habits.

If colour is to play any part in safeguarding these creatures, and it most certainly does, it is clear that each stage of life will call for something different from the others. It is seldom that all the stages of a butterfly have similar colouring, and they are generally marked by the most extraordinary and violent contrasts. The large cabbage butterfly, almost pure white and black, has a deep yellow egg. Its caterpillar is a mixture of

yellow, greenish blue and black. The pupa may be either bright green or creamy yellow. What an extraordinary difference there is between the black and yellow ringed caterpillar of the Cinnabar moth, and the rich crimson wings of the adult, or between the green and purple of the puss moth caterpillar and the sober grey of the moth. How are all these changes produced in one creature and what is the source and origin of them ?

I think we must necessarily tackle this question from the standpoint that all the creature contains and displays is derived from its food. Caterpillars are most voracious, often eating twice their own weight in 24 hours, so that they grow rapidly and store up large reserves of fat, from which to draw material for the complicated mechanism that develops during the pupal stage. Their food is the inner substance of the living leaf, and this, as we know, contains chlorophyll, the green colour of which forms the foundation of all butterfly colouring, not only in the sense that perfect food contains material from which any desired animal compound can be produced, but in a more direct and unequivocal manner.

Caterpillars Without Pigment

Let us try to conceive of a time before coloured caterpillars came into being. That there must have been such a time is certain, for this insect group is an offshoot or development of primitive forms. Even now, the large majority of insect larvæ are colourless, without pigment in the skin, but the white flesh is exposed through a transparent envelope ; and if such larvæ are exposed for any length of time to direct sunlight, they are killed. We must not overlook the fact that at such a time, animals of much higher development, certainly birds and mammals, did not exist, whereas to-day caterpillars are exposed to the attacks of thousands of creatures which make them staple food, and in spite of all protective devices could not hold their own, were it not for the enormous fecundity of the race. From 400 to 500 eggs is the normal progeny of one butterfly.

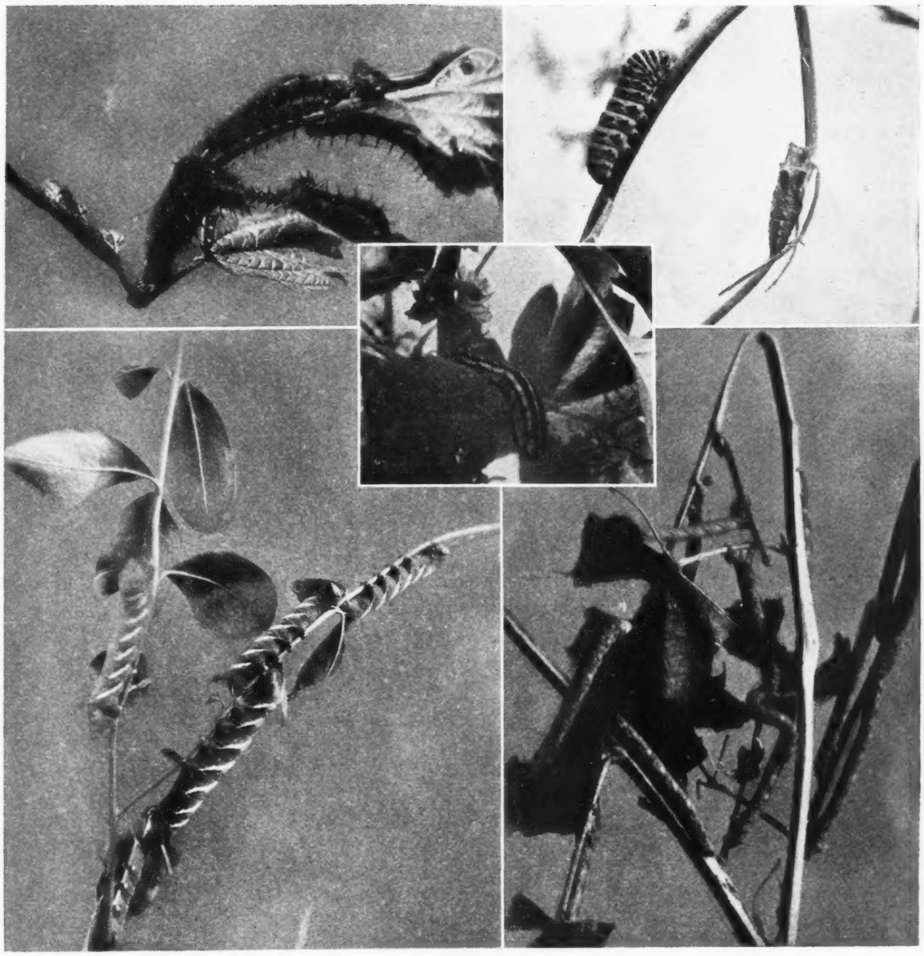
Assume then that the original caterpillar was a transparent creature, unable to live in direct sunlight, and that in a time of food scarcity it ventured from its retreat to find something edible. What would be the result ? I venture to say that it would depend on what the creature had been eating. If it had fed on colourless food, it would probably succumb to the sunlight, but if it had, either at night, or in some shaded place, partaken of fresh green leaf, its body would contain a certain amount of green pigment, which would afford some shield against the light. Although the normal reaction of animals to light produces a red-brown pigment, a derived vegetable pigment will serve the same purpose to a limited extent, and the exposure will certainly be gradual. One can imagine all sorts of alternatives. The habit of leaf feeding at night may have been contracted long enough to secure a green coloured race before any individuals remained exposed in daytime, and even then the exposure may have been limited to the first feebly lighted hours. The chances of survival would certainly be greater among those which had eaten the green pigment and exposed themselves more. In a word, the greener the caterpillar, the more likely its survival. Having stuffed itself with the new food, the caterpillar would crawl back to shelter and come out again when hungry to repeat the process, which all the time was tending to strengthen it. From the crude beginning, when the colour was merely borrowed from the food, to the stage when green becomes a permanent pigment of the skin, the action is precisely the same as in the human body. There the skin reddens with blood on exposure to the sun, and on longer exposure, produces a durable, but still removable pigment, which can, by generations of prolonged and complete exposure to the fullest light, become permanent and heritable.

The theory is confirmed by known facts. There are still many transparent caterpillars, through whose bodies the green food can be seen passing, and Professor Poulton has made experiments on the common cabbage caterpillar, feeding them on the unpigmented midribs of cabbage, the result being that their green colour faded to a pale tint with scarcely any pigment in it. The pigment of caterpillars is, therefore, derived directly from their food and it follows that it will be the proper green to match the leaf. Those who have collected caterpillars will know how closely the green ones resemble their food-plant. Even the same species, when it is capable of feeding on two different kinds of plant, varies in tint to match. There is thus a direct association between the particular green leaf hue and that of the caterpillar.

All Caterpillars Not Green

It is not difficult to understand that, if caterpillars were already green when birds began to attack them, any modification after that would inevitably be in the direction of producing still more perfect camouflage, since the birds would, in the long run, clear off those most readily seen.

All caterpillars are not green, and few, if any, are entirely and completely green, though there are enough examples to show that green plant-pigment accounts for the origin of this basic tint in leaf feeders. There are many in which the green is modified by streaks of yellow, whitish black, brown and innumerable other tints, while plenty have completely lost all trace of green,



Some spectacular caterpillars. Top, left: of Peacock butterfly, (Vanessa) black with spines. Top, right: of Swallow Tail butterfly (Achivus machaon), green with black spots. Centre: of Lackey moth, with longitudinal green, black and yellow stripes. Bottom, left: of Privet Hawk moth (Sphinx ligustri), green with diagonal red and white stripes. Bottom, right: of Biston hirtaria, mimicking twigs.

brown or reddish brown being a very common colour in many groups.

It is manifest that if a plant were always and entirely green, a green of the same shade would be a perfect scheme for caterpillar disguise, but it is only in very simple vegetable forms that green is uniform. As plants attain more defined and varied shapes, parts of their structure contain little or no chlorophyll. The evolution of these structures is, no doubt, an effect of the consumption of the plant by the animal. It would be impossible for the plant to shelter and feed a creature which would ultimately destroy it, and unless the plant puts up some sort of resistance, there will soon be an end of both. In primitive animals the biting organs are not able to deal with very hard material, so that any plants that develop something harder than the normal cellular protoplasm will to that extent resist the attacks of the animal. In this may be seen the germ of leaf and stem structure, consisting of specially indurated portions, unable to perform the digestive work of normal cell matter, but acting as channels for conducting nutriment from one part of the plant to another. These structures, seen in their primitive form as veins in a leaf, and in their highest development as stems, trunks, and branches, have a smaller amount of chlorophyll, so that the colour is a lighter green, or even entirely yellow. If an animal living on a plant with these veins retained a purely green colour, it would be relatively conspicuous, and it is only natural that selection should favour those marked with paler and generally yellow lines. Sometimes in the form of longitudinal stripes, sometimes as transverse rings, and frequently both, such markings are usual on green caterpillars, the very common Winter Moth being an excellent example.

With the gradual evolution of this indurated structure,

other logical developments follows. The induration is, in fact, caused by the accumulation of particles drawn from the soil. Of these, silica and calcium are the commonest, but iron, phosphorous, chlorine, potassium and magnesium are usually present. Each of these substances, when deposited, must effect the colour of the tissue. To the presence of these and the withdrawal of chlorophyll, as the epidermis hardens, is due the dark colour of the older stems of plants, culminating in the thick brown corky matter of tree bark.

These variations in plants must react on the caterpillars inhabiting them. It is by no means unusual for caterpillars to denude a plant of leaves, and however well they may have been concealed before, green caterpillars would then be completely exposed. It is certain that modifications of colour to suit such contingencies are urgently needed.

There does not seem to be any difficulty in accounting for them. In much more lowly animals there is some power, though feeble, of producing red or yellow pigment under the influence of light, and however much insect larvæ living in darkness have forfeited this power, any return to the habit of exposure must bring it into action again. No matter at what stage it began, whether as soon as the caterpillar began to expose itself, or even after the green pigment had become permanent, the reaction is always there in a varying degree, and the extent to which it will predominate over the green plant-derived pigmentation must depend on its usefulness. To put the matter quite clearly, let us suppose that the caterpillar reacts equally to light and plant-derived pigment, so that it becomes a mixture of green and red brown. It is clear that neither on the leaves, nor on the bark of a tree will it be completely disguised, but other things being equal, those which showed more green than brown would be safer on the leaves, and those which were more brown than green would be safer on the bark. It does not seem likely that an unduly long evolutionary period would be required to bring about a race of all-brown caterpillars by this process. There are many moth larvæ which feed at night, and during the daytime rest motionless on the stems. Some of these are all-brown, others yellow or greenish with brown markings. Many have a habit of stretching out stiffly at an angle from the stem, so that they completely resemble twigs. Even the shapes are modified to mimic excrescences like buds, and some have even perfect imitations of thorns.

If I have not entirely explained the route by which caterpillars became green or brown or both, I have, I think, made clear how complicated the reactions of one living creature on another may be.

Tracking the Atom

By R. Lang, Ph.D., A.Inst.P.

An exhibition illustrative of one of the most romantic departments of physical science is now on view at the Science Museum, South Kensington. Dr. Lang's introduction explains the principles concerned and gives a good idea of the fascination of the subject.

An atom and its several parts are far too small to be seen even by the most powerful microscope known to science. How then is it possible to study the collision of atoms and elementary particles of matter and to understand the nature of the disintegrations and transmutations that take place? It was in 1911 that Professor C. T. R. Wilson, working in the Cavendish Laboratory, Cambridge, the home of so many important discoveries concerning the constitution of matter, first succeeded in showing the tracks of individual parts of atoms—in particular alpha-particles (which are fast-moving positively-charged atoms of helium) and electrons—by the condensation of water-vapour on the charged particles called " ions " left in the track of these particles. The importance of this invention was well expressed by the late Lord Rutherford when he said that it was " the most original and wonderful instrument in scientific history." Wilson's work was recognised by the award of the Nobel prize in 1927. His original apparatus was in use for some twenty years and is now preserved in the National collection at the Science Museum, South Kensington, London. At the moment it forms the centrepiece of a special Exhibition which has been arranged in the Museum by Dr. F. A. B. Ward to celebrate the jubilee of its invention.

In essence the device depends upon the fact that if there is too much water-vapour in an atmosphere the excess condenses into tiny droplets forming a cloud or fog. Normally air is said to be " saturated " when any further addition of water-vapour results in condensation. In certain circumstances, however, air can be made to contain more water-vapour than the amount required for saturation ; it is then said to be " super-saturated." It has been known for a long time that under these

conditions condensation will commence on any minute particles of dust or other foreign matter which happen to be present. Such particles are termed "nuclei." Wilson discovered that ions (electrically charged particles of matter) can also act as nuclei for condensation. He was quick to apply this discovery to the development of the method of rendering visible the tracks of elementary particles of matter. The principle employed in his famous cloud-chamber apparatus is as follows: some air enclosed over water in the space *A* (in the diagram herewith) is super-saturated with water-vapour by suddenly expanding it. This expansion is carried out by allowing the piston *B* to fall instantaneously by connecting the space below it through the tube *C* to a large evacuated vessel. The air in the space *A* is first rendered dust-free by preliminary expansions whereby the dust is precipitated by the formation of clouds which are allowed to settle; any stray ions are removed by an electric field. If now, for example, a beam of alpha-particles is allowed to pass through the space *A* it will ionise the air in its path and after the sudden expansion minute drops of water form upon the ions so formed, thus rendering visible the path of the alpha-particles constituting the ray. The sides of the vessel being of glass it is possible to

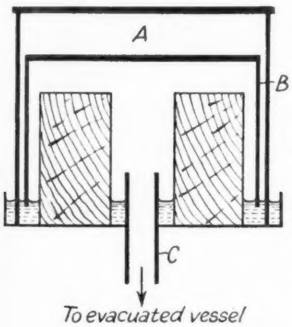
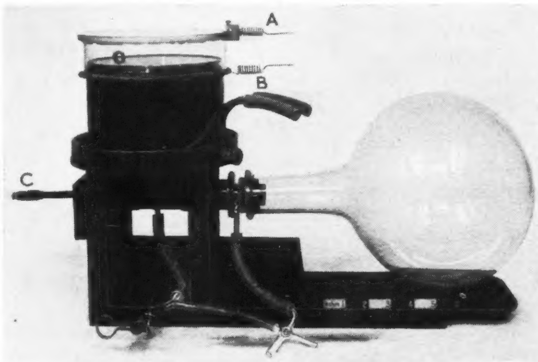


Diagram of C. T. R. Wilson's cloud-track apparatus. A is the expansion chamber; B the piston; and C the passage leading to the evacuated globe.

photograph these tracks either with an ordinary camera or with a stereoscopic one, or with two cameras making a large angle with each other.

Modern versions of the Wilson cloud-chamber are complex machines, often automatic in action, and sometimes employing vapour other than water-vapour. A large electro-magnet normally forms an integral part of such apparatus and is used to bend the path of the particle being studied into a curve, the radius of which gives essential information. Some of the elementary particles of matter have actually been discovered by means of these cloud-chamber photographs. Until recent years only two elementary particles were known: the proton, carrying a positive charge, and the electron, about 1,840 times lighter, carrying a negative charge. Recently, however, to these have been added the neutron, of about the same magnitude as the proton, carrying no charge as its name implies, and the positron, of about the same weight as the electron, but carrying a positive charge. A few months ago the discovery of yet another particle was reported as having been



[By permission of the Controller of H.M. Stationery Office.

C. T. R. Wilson's original cloud-track apparatus of 1911-12. *A = to battery for clearing residual ions; B = water for cooling; C = rod connecting to valve for making expansion.*

found in cosmic ray showers studied by the Wilson cloud chamber. This discovery has not yet been fully confirmed. The existence of another particle, the "neutrino," is postulated from theoretical considerations, but the search for it has not yet been successful.

As Dr. Ward remarks in the official handbook of this Jubilee Exhibition, "Perhaps its (the Wilson cloud-chamber's) chief function has been to confirm results done by other methods; the testimony of a Wilson track photograph often carries conviction where other evidence might fail to satisfy. In many cases the Wilson chamber yields quickly and directly information which could be acquired only very laboriously and indirectly by any other means."

Eighty photographs of particle-tracks, a unique collection, are on view at the Science Museum, all of them with clear and concise descriptions. Those who desire to catch something of the romance of the study of the ultimate structure of matter should make a point of visiting this exhibition before it closes at the end of February, 1938.

The office of the Society of Public Analysts and other Analytical Chemists has been transferred from 85, Eccleston Square, London, S.W.1,, to 7-8, Idol Lane, London, E.C.3, and Dr. C. Ainsworth Mitchell, hitherto Editor of THE ANALYST and Secretary to the Society, has resigned the office of Secretary and Mr. J. H. Lane has been appointed in his place. Communications relating to THE ANALYST, the society's Journal, should still be addressed to Dr. C. A. Mitchell, M.A., F.I.C., at 16, Blomfield Road, London, W.9

Book Reviews

Science and its Aims

What Science Really Means. By J. W. Friend and J. Feibleman. (Allen and Unwin, 7s. 6d.)

The authors have done scientists and, it may be claimed, engineers also (since these well-meaning people make the results of science available commercially to the rest of the world) a very good deed. In the past, the exponents of the scientific method, such as Faraday and Huxley, were regarded by the public with awe when they declaimed their latest discoveries; this tradition is maintained only in such venerable foundations as the Royal Institution. The damage to mankind that can be inflicted by the application of modern methods of destruction has provoked suspicion in an important fraction of the community, which is asking whether scientists are human and what is the purpose of science anyway.

The success of many books on speculative science offered to the reading public indicates a demand for enlightenment, and no doubt their readers feel some reward for their endeavour. It is improbable, however, that any one of them has been seriously affected in his daily life by such second-hand experience, whether by adopting in a small measure scientific methods of thought or by respecting others who have made them their primary purpose in life. The present authors try to get to the bottom of this matter and indicate the purposes of science and the methods of those who practise it. They do not necessarily condemn the presentation of highly speculative science to the general reader, on the basis that it can be of no use to him or to anyone else apart from the speculator, but present a balance between this extreme *mentalism* or idealism, which reduces the cosmos to a mathematical formula being experimentally examined by a creator, and the detached *positivism*, which is solely concerned with the collection of observed facts, carefully tabulated and verifiable by anyone who likes to take the trouble.

The entire book is a carefully thought-out defence and explanation of *empiricism*, the normal everyday tool of the practising scientist, the mixture and alternation of inductive and deductive reasoning, the only safe methods of thinking for intelligent men and women. By the one, universal truths are induced from collections of relevant facts, modified perhaps from time to time as our aids to perception become more and more refined in our search for new knowledge; by the other, specific phenomena are deduced from these truths for the scientist to search for experimentally and confirm, or induce the reason why not. The true scientist has little use for a mere collection of facts, however well attested, but he is also not going to mislead himself by idle speculations along lines which his normal experience indicates as unfruitful.

The authors also bring out the fact that a mathematical expression applicable to a set of phenomena is merely a convenient way of handling these data; the mathematical processes which are known to be true from experience of general application must always be checked in their new applications by reference to observation. Those who have been well educated in scientific method will welcome their claim that the bias of scientists is anti-metaphysical; metaphysics leads nowhere. Rationalists, who worship the supremacy of human intellect and reason, will find much to support their case against the reign of superstition. The reason why the social sciences have made so little progress is that they cannot use the principles of empiricism; apart from a few experimental communities in the U.S., which seem to be decaying because their main religious motives have been undermined, it is not possible to experiment with human beings. Life is too short for individuals to risk an accident in the experiment; it is more interesting to play with animals than with the human race, because no one will decide what qualities we desire in the future human being.

Meanwhile, humanity decays in numbers and possibly in intelligence. Nothing is being done, since science and scientists cannot and will not be responsible for the application of neutral knowledge, although they have been the authors of it. They would not be good scientists if they allowed themselves to be diverted to the multitude of social consequences of their work. They cannot value their knowledge, except in so far as it can be said to lead to more knowledge. If we lack an adequate scheme of social values, it is no fault of the scientists as such, but must be laid at the door of those who have accepted the responsibility of governing us; it is unfortunate that the conditions of appointment of our governors preclude them disclosing the truth, even if they know it.

The authors plead for a greater mingling of the sciences, a carry-over of method to those sciences which are behind in formulating principles of their own. Another purpose of the book is to restore public confidence in science and its aims, so that it is not forced eventually to be purely utilitarian. Unfortunately, the arguments are very closely put, and the general reader may find some difficulty in seeing the light; he may be assured, however, that the effort will be worth while, and that eventually he will acquire something which will be of help in understanding the complexities of the age.

L. E. C. Hughes.

The Chemistry of Life

Sterols and Related Compounds. By E. FRIEDMANN. (Heffer, 7*s.* 6*d.*)

Whether the next great advance in our understanding of the nature of life will come from more complete knowledge of the chemical structure or the physico-chemical behaviour of protoplasm, or from the study of viruses—those causative agents of disease which perhaps bridge the gap between living organisms and inanimate matter—or from some other aspect of scientific investigation it is as yet impossible to predict. But the sensational developments in the chemistry of the "sterols," which have taken place during the past five years suggest that this group of compounds will ultimately be found to play a conspicuously important part in the complicated tangle of physical and chemical changes which are inseparable from any form of life. Sterols are of widespread occurrence throughout the animal and vegetable kingdoms.

The characteristic sterol of the animal kingdom is cholesterol, a mysterious substance first isolated nearly a century and a half ago from human gallstones, and now known as a constituent of every cell of the animal body. Of its physiological function and mode of formation we are completely ignorant, although the richness of brain-matter in cholesterol has led to the speculation that it plays some part in mental and nervous processes. The exact molecular structure of cholesterol was finally determined in 1932; it contains a curious complex framework of carbon atoms which is now known to be present in a great diversity of natural products having varied and important physiological properties. The sterols of plants and lower organisms contain this same carbon framework, as do the acids of the bile, one of the functions of which is to promote resorption of fats in the intestine.

Closely related to cholesterol, but somewhat simpler in structure, are the "hormones" which are secreted by the sex glands and stimulate the development of the secondary sexual characteristics. The adrenal gland secretes several "hormones." One of these, necessary for the maintenance of life, contains the sterol carbon framework and is chemically related to the sex hormones.

A very near chemical relative of cholesterol is the provitamin which is converted by the action of sunlight into Vitamin D which, in a manner not yet known, is responsible for promoting the combination of calcium and phosphorus to form bone. It is especially remarkable that the same carbon framework which is present in all these substances is also found in such divers materials as the plant heart poisons, widely distributed in the vegetable kingdom and typified by digitalis, in the poisonous secretions of certain toads, and in the saponins. The latter are plant products which have the capacity to form soap-like solutions which readily foam, and also bring about hæmolysis of the red blood corpuscles. Lastly, it is suggestive that cancer, in all respects akin to the human disease, may be induced in small animals by chemical compounds, one of which is readily prepared in the laboratory by chemical transformation of the bile acids mentioned above. Possibly, the sterol group is intimately concerned, not only in the normal processes of life and health, but also, in abnormal conditions, with the causation of one of the most mysterious and deadly diseases which still afflicts mankind.

These are some of the fascinating themes which Professor Friedmann admirably reviews, using the conventional notation of organic chemistry, in the three lectures which are reprinted in this volume.

J. W. COOK.

Bird Watching in Africa

Wanderings of a Bird-Lover in Africa. By MADELINE ALSTON. (Witherby, 8*s.* 6*d.*)

In a short foreword to Mrs. Alston's book Lord Clarendon—to whose son, the late Lord Hyde, the book is dedicated—observes, "There are many lovers of birds, but there could be many more, and a book such as this may well encourage its readers, open their eyes to see, and open their hearts to care." The reviewer can join Lord Clarendon in hoping that this wish may be fulfilled. Mrs. Alston's pages are written for those who love birds and can find pleasure in following her wanderings to many delightful bird haunts in Cape Province, Natal and Zululand, Rhodesia, the Kalahari, Nyasaland and Portuguese East Africa.

The authoress knows her South African birds well and takes us with her on many rambles to out-of-the-way spots, drawing, incidentally, a picture—not always very heartening to the British—of the people with whom she comes in contact, and gives more than a passing glimpse of the alluring lands in which she has done her "bird watching." Perhaps the whole tone of the book is too incidental. One feels that with such opportunities of trekking as fell to her lot, and such a real love of her subject, Mrs. Alston should have given us rather more food for thought. In particular we should have welcomed more direct information about the ways and characteristics of the innumerable species which are mentioned, but for all that there are many little incidents related which touch and please the imagination.

For the average "bird lover" the book is written in rather too flowery a style. Such enthusiasm as Mrs. Alston displays over each encounter is apt to become wearying as is her employment of superlatives. The authoress wisely carried with her Stark and Sclater's *Fauna of South Africa*, and shows that she has kept up to date with her bird literature by reference to Captain Priest's *Birds of Southern Rhodesia* and Sir Charles Belcher's *Birds of Nyasaland*. When Mrs. Alston comes to speculate (p. 95) on the likelihood of some of the nightjars in Brazil being of the same species as those in South Africa, she is travelling too far beyond her own province. She can be assured that there are none and that not one parrot or waxbill is common to both regions.

The book is illustrated with a few pencil sketches by Moubray Leigh, some more pleasing than others—and an inaccurately coloured Frontispiece of the Knysna Lourie, which fails entirely to do justice to that beautiful bird or even portray its colours correctly. If this book succeeds, as Lord Clarendon suggests, in increasing the numbers of those who love Nature, and take an intelligent interest in Bird Preservation, I am convinced that none will be better repaid than the authoress, whose heart and soul are so obviously bound up with her subject. Messrs. Witherby's name is sufficient guarantee that the book is well produced. It is furnished with an adequate index.

D. A. BANNERMAN.

Wild Life at Home

Watching Wild Life. By PHYLLIS BOND. (Longmans, 6*s.*)

This book, so the author tells us in her introduction, is written for "just people: people who escape for half-days in the country from an official career . . . town-bred people who have come to live in the country. . . . They have no high hopes of adding to the world's knowledge." They only want to enjoy the country and its wild life.

Such a book was needed, and it certainly fulfils its purpose, for

Miss Bond is herself a good, though perhaps unduly modest, field naturalist. She sets out to prove that "observing nature need not be an expert's job." Evidently she is herself a keen observer, and her hints are therefore valuable to the inexpert. She descants upon the advantages of waking early and staying out late if you wish to learn the secrets of wild life, and has experienced the pleasures and excitements of "sleeping out." Early morning, she says, is generally the best time to see foxes, and the dusk is the only time when you may hope to see a badger; my own experience is that even then the hope is often deferred, for brock is the wariest and most suspicious of beasts.

She tells the watcher how best to take cover, explains the virtues of immobility, shows how there may be "news in a nutshell" of the mouse, nuthatch, squirrel, or vole that gnawed or split it, and reveals the importance of examining castings and droppings. There is an excellent chapter on tracking, and some pages on the patterns shown by birds in flight and how to memorise them. The tyro is warned that every bird which catches flies is not necessarily a flycatcher. Explaining that birds' bright spring colours are not due to new feathers but to the rubbing off of the tops of old ones, she remarks "how delightful it would be if our clothes got smarter the longer we wore them."

Her chapter entitled, "Noises Off," shows a remarkably keen sense of hearing; I can no longer hear slugs crunching seedlings, but Miss Bond can. She bids you remember that should you want to tame a shy, wild bird you should not look it in the face; it cannot meet the human eye.

Every bird-watcher has experienced the disappointments caused by the wariness of birds. Miss Bond tentatively suggests that sometimes the over-anxiety of the watcher may be communicated to the watched. Everyone knows how real and uncomfortable is the feeling of being watched by invisible eyes. I have myself often wondered whether there may not be some such telepathic transference. Edmund Selous believed that it existed between birds themselves: to extend it from these to human beings is only a short step further.

As a lure to suspicious fowl she recommends pine-kernels; I have found them a pleasant substitute for the squirming meal-worm. Like every real bird-lover she shows a healthy and natural loathing of egg-collectors. "Birds will be in danger until public indignation is so strong against the collector that none dare show his collection."

I can heartily recommend this book, not only to beginners, but to those who are already bird-watchers; they will find in it things that they did not know. It is delightfully written and is well illustrated by the author's own photographs. That of a bird's wing, showing the actual primary and other feathers, tells at a glance all that can be meticulously learned from a scientific wing-diagram.

E. W. Hendy.

Swift Movement in the Trees. By Phyllis Kelway. (Longmans, 6s.)

The author's keen observation of the intimate details of British natural history are well known to readers of Discovery, and she has the additional gift of recording her observations in a charming and easily-read style. The present book cannot fail to fascinate those who are fond of small animals and birds for their own sake, and at the same time, mingled with the "family gossip" of the various humble households of the author's acquaintance, are reported the results of observation which are of value to the systematic zoologist.

Moorhens, for example, are noted as regularly laying smaller clutches in the north of England than the south. The cause of this is worth ascertaining, as is the question of why a shrew should never yawn more than a certain number of times after waking up. To observe shrews at all is sufficiently remarkable; to know and record their habits in such intimate detail must be a feat hitherto unrivalled.

To the not unnatural question, what on earth have shrews and moorhens (not to mention toads, which also come into Miss Kelway's purview) to do with "swift movement in the trees," it is only fair to quote the parenthetic subtitle ("and at their roots"). Really the main title applies only to the opening chapters, a delightful study of the life of squirrels and a philosophic consideration of the psychologic differences between the red and the grey. Miss Kelway has summed up the grey "tree-rat" perfectly; he is "a lovable bounder," and his bounding depends largely on his exuberant digestion, wherein he has a tremendous advantage over his red cousin.

Anyone who has kept a pet is conscious of the marked individuality of animals; but it requires a special gift to get under the feathers of a particular moorhen (say) and present its character to us as that of a person. Readers should be grateful to Miss Kelway for such a presentation, and above all for the fact that she never exaggerates into sentimentality.

The photographs by the author, many of them of difficult subjects, are first-class.

Bantus and Pre-Bantus

Mapungubwe: Ancient Bantu Civilisation on the Limpopo. Edited by Leo Fouché. (Cambridge University Press, 50s.)

Readers of Discovery will already be familiar with Mapungubwe, the prehistoric site of South African civilisation, of which the discovery and the stages of excavation up to June, 1935, are recorded in this volume, edited on behalf of the Archæological Committee of the University of Pretoria by Prof. Leo Fouché of that University. The site and the main features of the culture brought to light in its excavation were described by Capt. G. A. Gardner in Discovery (No. 198, p. 178).

Mapungubwe, it may be recalled, is a small flat-topped hill with precipitous sides in the northern Transvaal. Persistent legends of treasure current among the natives, who held the hill in awe, attracted treasure hunters, who found a quantity of gold ornaments in a burial on the summit. As an outcome of this find the hill is now under public protection and its exploration is a joint undertaking of the Government and University with funds in part subscribed by the public. The actual excavation of the site, to which that of the adjacent Bambandyanalo has been added, is still proceeding; but the investigation as a whole is a matter of much greater magnitude, as it involves the cultural and ethnological comparison with the previously known and numerous prehistoric sites of the Transvaal region, as well as the investigation of the relation of Mapungubwe with the cognate culture of the Zimbabwe of Rhodesia, explored in 1929 by Miss Caton-Thompson.

The greater part of the present volume is taken up by a report by the Rev. Neville Jones, the well-known authority on the stone age of Rhodesia, who was in charge of the earlier stages of the investigation. He describes the "dig" and records the finds; but to his account are added reports by experts on the various classes of objects found. The pottery, for example, is analysed by Mr. J. F. Schofield, while the beads have been

discussed by Mr. H. Beck, the foremost authority on this important clue to cultural relations.

The human skeletal material found, owing to the nature of the soil, has proved difficult to handle. Under examination by Dr. A. Galloway and his team of students trained by Prof. Raymond Dart, it has provided a surprising result.

The site has afforded, in addition to a considerable amount of pottery, finds of copper, iron and one specimen of bronze; but the remarkable feature is the quantity of gold. This is not of local manufacture; and it is not an unreasonable assumption that its source is Zimbabwe. This conclusion is supported by the pottery, which apparently belongs to two cultural phases. As a whole the evidence points to a dating coincident with the later period at Zimbabwe, and provisionally may be put at somewhere about the 15th century.

Culturally, Mapungubwe, like Zimbabwe, is identified as what is known familiarly to most as "Bantu," or, as local anthropologists now term it, "South African Negro." Here, however, comes in the surprising result of the examination of the skeletal remains to which reference is made above. This material the authorities are emphatic in regarding as Bush-Boskop—in other words as belonging to a pre-Bantu race. The puzzle of the incompatibility of culture and skeletal remains, thus revealed, remains unresolved. Certain suggestions are made, but until the evidence of the further excavations now proceeding is available, discussion is likely to bring little profit.

The Government of the Union of South Africa, the University of Pretoria and all concerned with the excavation are to be congratulated both on the character of their undertaking and the scholarly manner in which the results of its investigation are being reported.

E. N. Fallaize.

Aboriginal Birth-Theory

Coming into Being among the Australian Aborigines By M. F. Ashley-Montagu. (Routledge, 21*s*.)

In the closing years of last century anthropologists were thrown into a state of amazement by a remarkable report from Australia. Baldwin Spencer and F. J. Gillen announced as a result of their joint investigations among the Arunta of Central Australia, that these primitive tribes were ignorant of the facts of procreation and believed that children were born in consequence of the entry into the body of the mother of an ancestral spirit from a remote mythological past. The idea that such an ignorance of the facts of conception was possible was not entirely new. It has been suggested tentatively by E. Sidney Hartland (not "Sir" as Dr. Ashley-Montagu calls him, nor then even "Doctor") some years before in his "Legend of Perseus," as an explanation of the widely distributed legends of supernatural or miraculous births, of which the legend of Perseus is one version. This, however, referred to a remote past, whereas the Arunta were a living and modern people. Many anthropologists felt themselves unable to accept the statement at its face value, and tried to explain it away as only a partial record of the facts. Others argued that it was an aberration, or a sign of cultural degeneration in the Arunta.

Controversy raged over this question for some years. On both sides it was agreed that such a view of birth was of vital import for the study of the socio-religious ideas of the Australian aborigines, as well as of other primitive peoples. It was the germ from which Sir James Frazer developed his theory of conceptional totemism. Since those days this belief and the ignorance of the biological fact of paternity have been reported, not only from other parts of Australia, but from many parts of the world; and the fact is not now in dispute. Dr. Ashley-Montagu, however, is the first to attempt a complete evaluation of the facts in their social setting.

Notwithstanding argument to the contrary Dr. Ashley-Montagu shows that this form of belief as to the nature of conception is typical throughout aboriginal Australia; but he goes on to demonstrate that the absence of recognition of the biological relationship affects not only the father, but also the mother, although early discussion assumed the contrary, namely, that the physical relation to the mother was obvious—a view which has been contradicted tentatively only by later observers. The consequence of this default in recognition of biological relationship, the author demonstrates, is that parenthood becomes a purely social relation, a mechanism to ensure that the ancestral spirit assumes its correct status in the group organisation, the mother being merely the vehicle.

The author's argument, as will be apparent, imposes a new line of approach in the discussion of Australian social organisation. This he himself has here discussed in some detail in relation to a number of sociological problems, which have long exercised the ingenuity of anthropologists in argument.

The value of Dr. Ashley-Montagu's important contribution to the study of the Australian aboriginal is enhanced by Professor Malinowski in a foreword in which the aims of "functional anthropology" are stated and contrasted with recent developments in the methods of study of social anthropology in America.

E. N. Fallaize.

Dynamic Colour

Coloured Light. By A. B. Klein. (Technical Press, Ltd., 30*s*.)

This is the third enlarged edition of the author's previous *Colour-Music, the Art of Light*, in which the theory and technique of combining colours in patterns for media of æsthetic and emotional experiences are developed. The text serves the very useful purpose of collecting all that previous workers (including the author) have done in this field, and it seems a pity that the public or even a small coterie of it have not patronised this, even as a high-brow novelty. Static colouring in the art of decoration and painting is well appreciated, but the mobile art, either on its own or in parallel with music, thus giving the eye something to absorb while the ear is concerned with its channel of information, does not seem to have caught on; apart from recording a number of Press impressions of special demonstrations of various systems, the author does not seem to be very hopeful. Horizon and cloud machines are often found in theatres, but their presence is subsidiary to the main effect and merely helps to add a little realism without any theoretical sanction. The author shows that he has a good engineering grasp of his subject and is not to be led away by erroneous theories respecting relationships between the frequencies of sound waves and light waves; he has little use for analogies. He is more concerned with other people's theories than with any of his own, but his summary of theories of colour harmony is of value over a wider field than the author has immediately in view, such as in coloured fountains and in illuminated advertisements.

The author does not seem to see that the use of colour in films, either for abstract purposes or in decorating ordinary photography, may have altered the position markedly, since such films can be duplicated indefinitely and projected on normal machines with no further demand than that the right carbons are used for arcs. The registration of reproducible colours must

mean that the expensive and elaborate colour-projection machines are no longer necessary. If we remember rightly the author deals with this problem in his book on colour cinematography and possibly his system, Gasparcolor, which was used by the Post Office for abstract advertising films, was a pioneer in this respect.

L. E. C. HUGHES.

Television Engineering. By J. C. WILSON. (Pitman, 30s.)

One can say without reservation that this is the best book on the general problem of television that has yet appeared; it is decorated with a Foreword by J. L. Baird, who was the pioneer of a practicable system in this country, although time showed that the problem was greater than could be undertaken successfully and brought to a commercial conclusion by him and his colleagues. Any system which is going to attract public attention on a reasonable scale must be the product of a highly organised research association with ample financial resources; a system stands or falls on whether, apart from all technicalities, the producers of the programmes can handle the system with sufficient ease for them to think freely in terms of the new medium. It is self-evident that the viewer must be able to see clearly what is being presented to him. The difficulties can be appreciated only by the technician, and it is to him that the present book is addressed; to the general reader the science of television must remain closed; it can be described to him only in very general terms. The author has made a wide study of the theoretical sides of many systems and shows this by the well-balanced arrangement of his information; he has had first-hand experience with several systems and this is reflected in the quality of his work.

Modern Rubber Chemistry. By HARRY BARROW. (Hutchinson, 18s.)

This book gives a comprehensive survey of the behaviour of rubber and latex in every phase of their commercial applications. The author has made a special effort to present his facts in a manner which can be easily understood, and has resorted to analogies, which may be considered too popular for the scientific mind and yet capable of making appeal to a very wide circle of readers who are interested in the subject of rubber. He complains very wisely that "chemistry as a whole suffers from too much unexplained jargon," and suggests that the progress of rubber in its industrial and commonplace applications might easily be retarded by explanations and outlook which are too scientific.

Towards Angkor. By H. G. QUARITCH WALES. (Harrap, 12s. 6d.)

Any book by Dr. Quaritch Wales on the civilisation and culture of Greater India is necessarily of importance, and this is especially so when he directs his attention to the era preceding the much-popularised Angkor. This book is a story of a journey from Lopburi by way of the extremely interesting site of Sri Deva to Angkor; but the author's pen travels over far wider territories, to Prome, Nakon Sri Thammarat, Takuapa, Chaiya, even to Palembang in Sumatra and to Bali. In fact, no place escapes mention which had any bearing upon the way in which cultural influences spread eastward over Greater India. There are many extremely interesting legends related, while the quantity of facts assembled is prodigious. The only complaint the reader may have is that the continuity of the story is lost in the maze of names and dates. Also, a fuller account of Dr. Wales' excavations at Sri Deva would have been welcome. A particularly interesting chapter is devoted to that little-known figure, "the King of the Mountain," an Indian conqueror whose character can be deduced from the evidence which remains, but whose name is lost. The forty photographs are excellent, and not the least virtue of the book is its tasteful binding and enticing dust-cover.

Communication Has Been Established. By ASTLEY J. H. GOODWIN. (Methuen, 10s. 6d.)

A history of communications is a history of civilisation, and although a knowledge of ethnography may be of advantage in a study of communications, the latter is in much greater degree useful in studying the former. By keeping this in mind, Mr. Goodwin has produced a book which will bring an understanding of how the peoples of the world evolved more swiftly and surely than any purely ethnographic work. It can safely be predicted that excerpts from this book, read in schools, with his excellent line sketches perhaps reproduced on the blackboard, will enthral the listeners and give them a very solid foundation on which to build a knowledge of the people of the world. The author deals first with land transport, starting with the Palæolithic, and then with the parallel development of water transport. Particularly interesting chapters deal with the silk roads of Asia and the Roman network of roads. Finally two chapters deal with sign and sound communication and the beginnings of language. An interesting parallel is drawn between the spread by explosion of Neolithic culture and conditions to-day. "We are," writes Mr. Goodwin, "but ripening a newer, more mobile civilisation in anticipation of the next revolution when our own suicide will enrich the world."

Faults are few. It is rather surprising, however, to find the author writing "the diameter of a railway wheel is never over two feet, so that the leverage is relatively small, and curves on the track are kept long. . . ." Locomotives commonly had driving wheels (fixed to axles) of nine feet diameter at the end of the last century, and six and a half feet is the usual diameter for express locomotives to-day. Further, the celebrated Gotham curve on the High Peak branch of the L.M.S. railway has a radius of only fifty-five yards, and is worked over by normal goods locomotives.

An Introduction to Bacteriological Chemistry. By C. G. ANDERSON. (E. and S. Livingstone, 10s. 6d.)

A steady increase in the utilisation of microbiological methods and products in industry, as well as an increased number of academical investigations into the mechanism by which bacteria, yeasts and fungi gain the energy for growth and are able to synthesise fermentation products, has made the publication of this book desirable. The text is based on lectures which have been given as part of the course for the academic diploma in bacteriology of the University of London and to students of an honours course of bacteriology at Edinburgh. It makes no attempt to be encyclopædic, the main object in view being to give students, and research workers generally, some understanding of the chemical behaviour and nature of the organisms which they are handling. The first few chapters deal with such general considerations as hydrogen-ion concentration, colloids and adsorption, enzymes, and the chemical constitution of the organisms; the remainder of the book is devoted to metabolism and immuno-chemistry, and there is an appendix relating to the isolation and identification of metabolic products.

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(*Continued from page* ii)

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